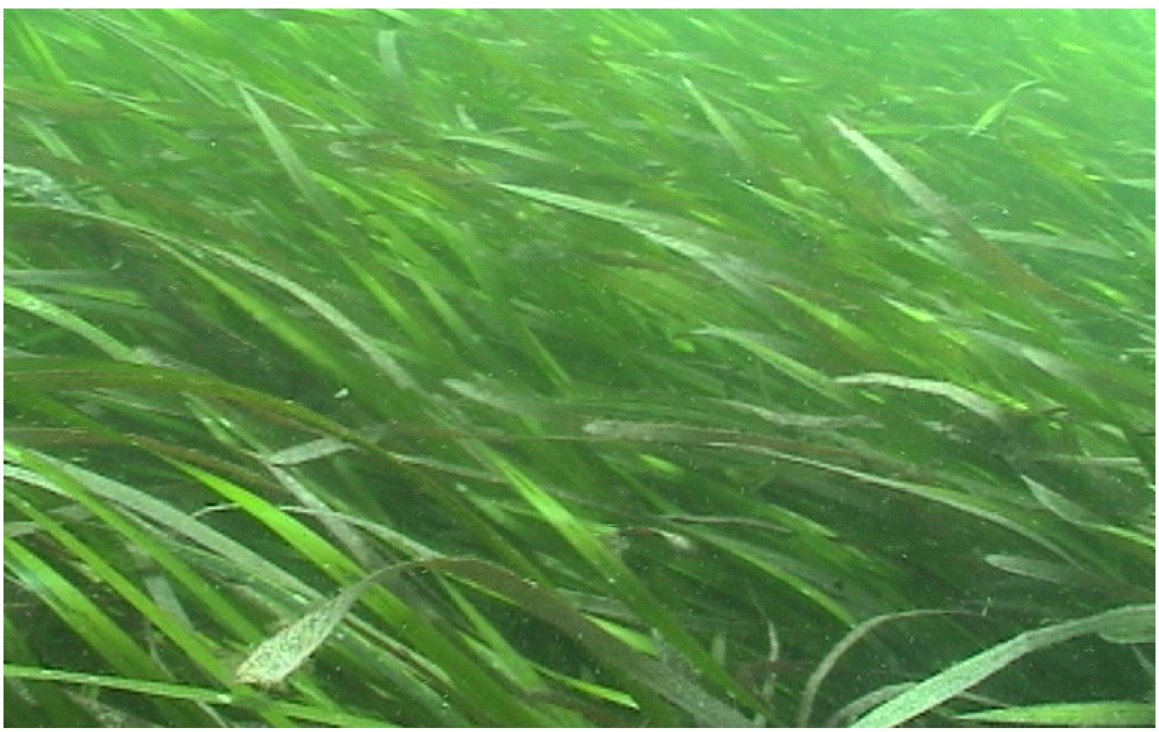
APPENDIX B

Eelgrass Capacity and Management Tools



"The following technical report reflects the findings and data available at the time the report was prepared and may not represent the current conclusions and steps forward in the main text of the HAMP, which has been updated after the completion of these reports. These more detailed technical reports provided in the appendices represent the foundation for the overall approach to the HAMP, but are not "living" documents that reflect updated steps forward, costing, quantities, etc. presented in the main text of the HAMP. The main text of the HAMP represents more current information and recommendations based on updated information, new studies, changes in conditions, new funding sources, and/or new regulations."

HARBOR AREA MANAGEMENT PLAN

EELGRASS CAPACITY AND MANAGEMENT TOOLS

Technical Report

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April 2008; Revised June 2009

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1.0 EELGRASS CAPACITY AND MANAGEMENT TOOLS

1.1 Introduction

The marine resources of Newport Harbor are extremely diverse and rich and are extremely important to the health and maintenance of nearshore coastal resources. The City of Newport Beach is committed to achieving a sustainable Newport Harbor area through the projection and improvement of harbor marine resources, including marine plants, invertebrates, fishes, seabirds, marine mammals, and the habitats that they are associated with.

One of the most important biological resources within Newport Harbor is eelgrass (*Zostera marina*). It is considered wetland habitat by state of California and federal wetland definitions and is protected by a no net loss wetlands policy. Any development that has a potential to adversely affect eelgrass must include provisions to avoid, reduce the level of impacts, or compensate for losses of eelgrass habitat values.

1.2 Objectives

The objectives of this technical report are as follows:

- Identify historical and current eelgrass distributions in Newport Bay.
- Identify key issues related to resource management conflicts between eelgrass and the management goals of Newport Harbor.
- Provide recommendations for developing and implementing an Eelgrass Management Plan for Newport Harbor.
- Provide information and data requirements needed to develop a long-term management program of eelgrass bed resources in Newport Bay.

1.3 Organization

This technical report provides a detailed review of eelgrass biology and its distribution and abundance in Newport Bay. Data are then presented to determine the regions within the Bay where the potential for future eelgrass sustainability sites are the highest. A plan for the long-term mitigation requirements related to harbor infrastructure projects impacts on eelgrass bed resources is presented. The report concludes with data requirements to implement a long-term mitigation program.

2.0 EELGRASS BIOLOGY AND DISTRIBUTION IN NEWPORT BAY

2.1 Importance of Eelgrass

Eelgrass (Figure 1) is a marine flowering plant that grows in soft sediments in coastal bays and estuaries and occasionally offshore to depths of 50 ft. Eelgrass forms meadows on mudflats and subtidal sediment in bays and estuaries. The presence of eelgrass in Newport Harbor is a biologically important feature because of the high biological productivity associated with eelgrass beds. Eelgrass meadows form a basis of primary production that supports ecologically and economically important species (Orth et al., 1984; Thayer et al., 1984).

Source: CRM, Inc.
Figure 1. Eelgrass (*Zostera marina)*

As a primary producer, eelgrass fixes carbon at rates that are equivalent to or exceed the rates of the most intensively farmed agricultural crops (Thayer et al., 1984). Epiphytes such as diatoms and green algae that attach to eelgrass blades add to this high level of productivity (Thayer et al., 1984; Phillips and Menez, 1988). The organic matter in the form of shoots, blades, and roots is transferred to both invertebrate and vertebrate secondary consumers that feed on the particulate matter through the detrital feeding pathway. In addition, invertebrate and fish predators forage upon the diverse types of detrital feeding invertebrates which congregate within eelgrass habitat.

Eelgrass meadows (and subunits called “beds” and “patches”) are important habitat for invertebrates as a source of food and attachment and for marine fishes that seek the shelter of the beds for protection and forage on invertebrates that colonize the eelgrass blades and sediments in and around eelgrass vegetation.

Eelgrass canopy (consisting of shoots and leaves approximately 2–3 ft long) attracts many marine invertebrates and fishes, and the added vegetation and the vertical relief it provides enhances the abundance and the diversity of the marine life compared to areas where the sediments are barren. Juvenile California halibut (*Paralichthys californicus*) and California spiny lobsters (*Panulirus interruptus*)—which are of sports fish and commercial value as adults—use eelgrass beds as a nursery habitat. The vegetation also serves a nursery function for many juvenile fishes, including species of commercial and/or sports fish value (e.g., California halibut and barred sand bass) and federal Fishery Management Plan (FMP) groundfish species (e.g., lingcod, and Boccaccio rock fish).

A diverse community of bottom-dwelling invertebrates (e.g.., clams, crabs, and worms) live within the soft sediments that cover the root and rhizome mass system. Eelgrass is an important contributor to the detrital (decaying organic) food web of bays because the decaying plant material is consumed by many benthic invertebrates (e.g., polychaete worms) and reduced to primary nutrients by bacteria. This carbon is then transported offshore and becomes important sources of nutrients for coastal food webs.

Eelgrass coexists and competes for bottom habitat and sunlight with benthic algae. For example, eelgrass meadows in Newport Bay often co-occur in the low intertidal or shallow subtidal zone with green algae (*Enteromorpha spp)* and in deeper parts of the meadow, with brown algae (*Ectocarpus*), and red algae (*Acrosorium* and *Gracilaria)*. Eelgrass in Newport Bay and other Southern California bays also support unusual or rare species, including Pacific seahorse (*Hippocampus ingens*) that became established as a result of warm water intrusions into Southern California produced by El Nino conditions and the juvenile broad-eared pecten (*Leptopecten latiauratus*) which attaches to eelgrass shoots and blades.

Eelgrass meadows are also foraging centers for endangered seabirds, such as the California least tern (*Sterna albifrons browni*) and California brown pelican (*Pelecanus occidentalis*), that feed on topsmelt and anchovy that congregate within eelgrass meadows.

From a recreational standpoint, eelgrass meadows in Newport Bay provide fishing opportunities for boat and kayak fishermen; this translates into a consistent economic base for businesses within Newport Beach, including the recreational fishing industry, boat and kayak rental/retail stores, and food concessions. Detailed fishing charts of Newport Harbor were recently produced that include the Coastal Resources Management, Inc. (CRM, Inc.) 2003–2004 eelgrass habitat maps produced for the Harbor Resources Division (http://www.bajadirections.com).

2.2 Key Issues

From a resource management perspective, the presence of eelgrass within Newport Harbor often conflicts with the development and the maintenance of federal, state, city, and residential infrastructure. From a geological perspective, eelgrass beds dampen wave and current action, trap suspended particulates, and reduce erosion by stabilizing the sediment (National Marine Fisheries Service (NMFS) 1991, as amended). Once established, eelgrass colonization will promote additional shoaling that can be a navigational hazard. Dredging of these shoals; maintenance of navigational channels, bulkhead, pier and dock construction and/or maintenance; and beach nourishment along the shoreline of Newport Harbor directly affects eelgrass through burial or removal of vegetation and a loss of eelgrass function as a wildlife habitat. Other activities may also indirectly affect the distribution and abundance of eelgrass. Dredging activity, pile driving activity, and stormwater flows via street-end storm drains and Upper Newport Bay that discharge into Newport Harbor increase water turbidity and decrease the amount of underwater irradiation that reaches the bayfloor. Secondary effects from boat dock and pier construction will permanently shade soft bottom habitat. Because eelgrass is considered wetland habitat by state of California and federal wetland definitions, it is protected by a no net loss wetlands policy. Any development that has a potential to adversely affect eelgrass must include provisions to avoid, reduce the level of impacts, or compensate for losses of eelgrass habitat values.

These projects are undertaken as federal, state, local agency projects, or individual resident's projects which do not qualify under the City's Regional General Dredging Permit (RGP 54) due to the presence of eelgrass within 15 ft of their docks, bulkhead, piers, or beach nourishment projects. More detailed and, to the homeowners, more costly analyses are required under these circumstances if they do not qualify for inclusion in the RGP.

The City of Newport Beach has an adopted a Coastal Commission-approved land use plan (LUP). The LUP acknowledges that the need to maintain and develop coastal-dependent uses may result in impacts to eelgrass. To mitigate the potential impacts to eelgrass of dredging and development, the LUP requires the avoidance where possible and restoration where avoidance is not practical:

The City and all the stakeholders need to develop an eelgrass mitigation program to allow the City to go forward with dredging and construction activities that are necessary and will impact eelgrass.

2.3 Eelgrass Distribution and Abundance

Many factors, both abiotic and biotic, have an influence on eelgrass distribution and abundance. These factors are discussed below.

2.3.1 Sediments

Eelgrass colonizes a range of sediments varying from firm sand with moderate wave action to soft muds in quiet bays (Phillips, 1974). In Newport Bay, eelgrass colonizes in sediments that range from fine sands to silt/clay (Coastal Resources Management, Inc., in progress). Eelgrass grows in predominantly fine sand sediments between the entrance channel to Harbor Island. In most other areas of the Bay, eelgrass colonizes siltier, less compact sediments. Results of sediment grain-size analysis in eelgrass beds and in sediments where eelgrass is not found in Newport Bay (CRM, Inc. in progress) indicate that on the average, eelgrass can grow in a wide range of sediment types with as little as 4% sand (Linda Isle Inlet) and as much as 97% sand (near the harbor entrance). On average however, sediments tended to consist of approximately 10% more sands in eelgrass beds than in unvegetated sediments, although the proportions of sand and silt/clay can be highly variable. Typically, sediments exhibit a decreasing grain size with increasing depth in Newport Bay (Ware, 1993; Chambers Group Inc. and Coastal Resources Management, 1998; Chambers Group Inc. and Coastal Resources Management, 1999) as well as lower velocity current regimes.

2.3.2 Depth Distribution

The upper elevational range limit of eelgrass on naturally sloped shorelines is primarily regulated by desiccation, sediment stability, and wave shock (Phillips, 1974). In Newport Bay, this limit appears to be approximately at the mean lower low water (MLLW) mark (0.0 ft), although it can occur as high as +1 ft MLLW. However, in many areas of Newport Bay and other modified Southern California embayments, its upper range limit is also affected by dredging and bulkheading activity that eliminates natural intertidal slopes and eelgrass meadows. Within Newport Bay, eelgrass is found at depths as great as -25 ft MLLW in the entrance channel, although it more typically occurs in other areas of Newport Bay at depths from 0.0 ft and -8.0 ft (Ware, 1993; NMFS, 2003; CRM, Inc., 2005 and 2008; CRM in progress; Chambers Consultants Inc. and Coastal Resources Management, 1998 and 1999).

2.3.3 Wave/Current Energy

Some water motion is needed to supply nutrients to the plants, cool the flats, and prevent the buildup of floating organic matter that can smother eelgrass (Thom et al., 2003). Strong waves and currents will erode the sediment in an eelgrass bed (Phillips, 1984).

Light, temperature, and salinity also control growth and productivity of seagrasses (Thayer et al., 1984; Backman and Barilotti, 1976; Zimmerman et al., 1991). Of these, light is the factor which often controls the depth, distribution, density, and productivity of seagrass meadows (Backman and Barilotti, 1976; Zimmerman et al., 1991).

2.3.4 Light Penetration

In Newport Bay, as in other shallow-water embayments, light penetration is affected by parameters, such as time of day and year, tidal condition, suspended organics and sediment input into the bay from dry-season runoff, winter storms, plankton blooms, shading from docks and boats, and in-bay activities such as dredging and boating activity (ACOE, 1998; 1996; MBC Applied Environmental Sciences and SCCWRP, 1980; CRM, Inc. in progress).

Light penetration is better during the incoming tides compared to outgoing tides which carry higher levels of suspended organics and sediments out of Newport Bay. Zimmerman et al. (1991) estimated that eelgrass in San Francisco Bay required between three and five hours a day of irradiance to maintain carbon balance and growth and suggested that eelgrass is adapted to extremely low light availability.

Higher water turbidity in coastal embayments limits eelgrass depth distribution to intertidal and shallow subtidal environments (Zimmerman et al., 1991). This is reflected in Newport Bay with eelgrass exhibiting a greater depth range nearer the harbor entrance compared with eelgrass beds located near Harbor Island, Balboa Island, Linda Isle, and Upper Newport Bay where water clarity is poorer and sediments are much finer (CRM, Inc., 2005). Generally, the compensation depth for seagrasses is approximately 11% of the available surface irradiance (Duarte, 1991).

Eelgrass growth and distribution is also affected by a decrease in solar radiation resulting from seafloor shading from docks, piers, and vessels. Studies indicate that shoot densities of seagrasses decrease near docks and pilings and that the construction of docks and piers can lead to a permanent loss of seagrass vegetation (Beal and Schmit, 2000). In addition, the height of pier structures will affect how much light can penetrate beneath the piers. In locations such as Corona del Mar where piers are elevated several feet off of the sediments, eelgrass will grow underneath the piers. In other areas, structures (e.g., along Balboa and Harbor Island piers and gangways) are not as elevated and allow less light penetration beneath. Consequently, eelgrass may not grow as well or may be absent altogether underneath these structures (Coastal Resources Management, Inc., 2005).

2.3.5 Temperature

Eelgrass is a eurythermal species (Phillips, 1984). Its optimal temperature distribution is between 10^{o} Celsius (C) and 20 ^{o} C (50–68 ^{o} F). Its extreme temperature ranges may vary from -6 ^{o} C in Alaska to 40.5 ^{o}C (21.2^{-}104.9 ^{o} F). Therefore, water temperatures in Newport Bay are generally not a limiting factor for eelgrass growth and distribution. During late summer, water temperatures in Newport Bay can exceed 21 ^{o} C for sustained periods of time (CRM, Inc., in progress) that promote seasonal biofouling of the blades. The heavy blades then bend and come in contact with the sediments that lead to eventual burial and loss of eelgrass above-ground biomass.

Eelgrass may display some genetic and/or environmentally associated variations in response to water temperature and/or light requirements. For example, wider-bladed meadows of eelgrass occur primarily in the deeper, cooler entrance channel waters of Newport Bay, whereas a narrower-bladed variant is found throughout the other regions of Newport Bay in shallower, warmer conditions (Figures 2 and 3). Recently, wide-blade eelgrass in the Channel Islands was identified as a different species (*Zostera pacifica*) (Coyer et al., 2007), whereas before it was considered either a subspecies (Z. *marina var latifolia*) or a separate species (*Z. asiatica*) (Phillips and Wyllie-Echeverria, 1990). Currently, it is not known if the wide-blade variant form in the entrance channel is the subspecies *Z. marina var latifolia* or if it is considered to be *Z. pacifica*. The genetic differences and the relative differences in depth and geographical distribution of the two forms within Newport Bay suggest that future mitigation efforts need to take into account the morphological and genetic differences when collecting donor material for specific projects and the selection of the eelgrass mitigation site.

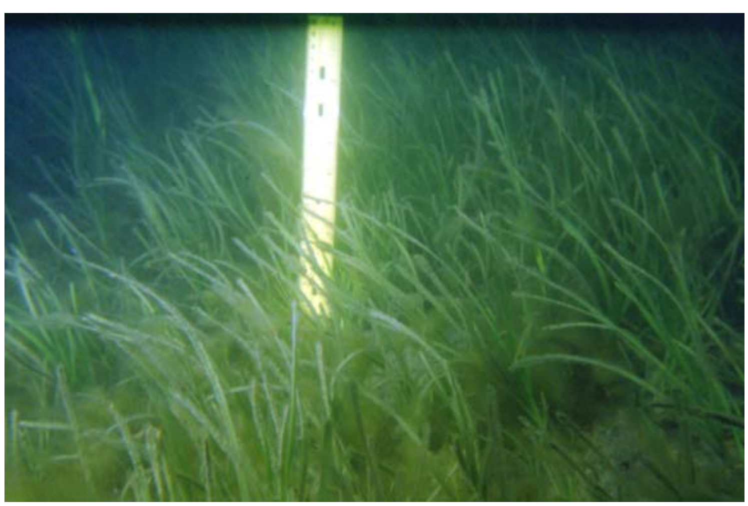


Figure 2. Narrow-Bladed Eelgrass

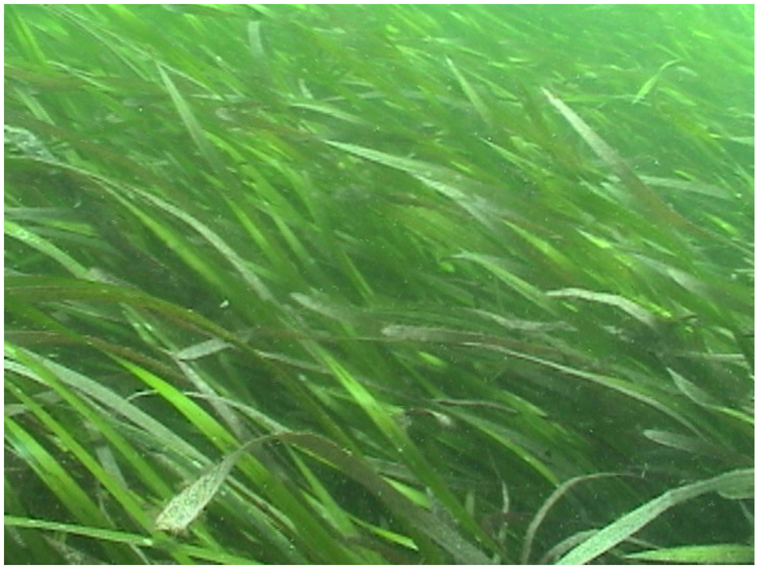


Figure 3. Wide-Bladed Eelgrass

2.3.6 Salinity

Eelgrass is also a eurysaline species, tolerating a wide range of water salinities, including the range of salinities that Newport Harbor experiences. It has been documented to grow at stream mouths when the water is fresh at low tide (Phillips, 1984) but does not grow in persistent freshwater. At the other extreme, eelgrass can grow in waters of extreme salinity (42 ppt). In Puget Sound, eelgrass grows best in a salinity of 20 to 32 ppt. Phillips (1972) found that most (70%) eelgrass seed germination occurred at 5 to 10 ppt at all temperatures, although at 10 ppt, seed germination often doubled from 10° C to 15° C but did not do so in full strength seawater (30 ppt). Newport Bay salinity, on the average range between approximately 30 to 33 ppt, although during wet periods, surface salinity may decrease to below 25 ppt for short periods of time. In addition, salinity is typically lower in the Upper Bay due to runoff from the Newport Bay Watershed.

2.3.7 Oxygen

Under normal growing conditions, oxygen is not a limiting factor for eelgrass. However, during periods of high turbidity which may result in significant light limitation and decrease in photosynthesis and oxygen production, eelgrass root and rhizome tissue may experience periods of anoxia. While eelgrass tissue apparently can withstand periods of 24 hrs of anoxia (Smith, 1989), the long-term cumulative effects of prolonged anoxia are not known, but it is possible that eelgrass distribution, particularly at its deeper limit, may be negatively affected (Zimmerman et al., 1991).

2.3.8 Nutrients

Eutrophication is one of the main causes for decreased light availability that can lead to a decline of eelgrass populations. As excess nutrients stimulate phytoplankton growth, light penetration to the plants growing at depth is reduced. Increased epiphytic (and benthic) macroalgae growth from excessive nutrient loading can shade and suffocate eelgrass plants. As light diminishes, the plants develop thinner blades, leading to lower rates of productivity and a decrease in biomass and lower shoot densities (Denison, 1987).

2.3.9 Synergistic Effects

There is a lack of available data that compare submarine light levels, turbidity levels, eelgrass compensation depths, and temperature variations within vegetated and unvegetated regions of Newport Harbor. These data are required to understand the observed differences in eelgrass cover and density among the various regions of the bay, and to identify areas that may or may not be suitable for future eelgrass transplants. Consequently, studies are currently being conducted that will address these parameters and how they influence eelgrass distribution in Newport Bay (CRM, Inc., in progress).

2.3.10 Summary of Other Relevant Scientific Information Regarding Eelgrass Structure and Function

Few studies have directly approached the biological diversity and habitat value of eelgrass within Newport Bay. These studies are critical to understand the relative habitat importance and value of eelgrass habitat within the various regions of Newport Bay, and to be able to make informed management decisions relative to eelgrass mitigation. For example, do sparse, low-density, and patchy eelgrass beds along Mariner’s Mile provide the same habitat value for marine life as eelgrass beds near the Harbor Entrance Channel, and should all eelgrass areas of Newport Harbor be treated the same from a harbor management perspective?

While not comprehensive or quantitative, a list of organisms observed during the 2003–2004 bay wide eelgrass habitat surveys included 63 species. Of these, one was a sulphur bacterium, nine were algae species, two were seagrasses, 31 were invertebrates, and 20 were fishes. Data were not analyzed by region with the harbor. During eelgrass surveys conducted in July 1999, 28 species of macro invertebrates were observed living on eelgrass or in sediments of eelgrass beds. The most common forms were speckled scallops (*Argopecten aequisulcatus),* anemones (*Pachycerianthus fimbriatus*), snails and sea slugs (*Bulla gouldiana and Navanax inermis*) and nudibranchs (*Anisodoris nobilis*). During both the 2003–2004 and 1999 surveys, commonly encountered fish included topsmelt (*Atherinops affinis*), spotted sand bass (*Paralabrax maculatofasciatus*), barred sand bass (*P. nebulifer*) and round string ray (*Urolophus halleri*). Fourteen of 16 species of fish observed during July 1999 eelgrass bed surveys were associated with eelgrass habitat (Chambers Group Inc. and Coastal Resources Management, 1999).

Directed research in other Southern California embayments concerning the value of eelgrass beds as a nursery or wildlife habitat not received high priority, although several studies (MBC, 1986; Hoffman, 1986; Hoffman, 1990; Hoffman, 1991) suggest the marine life of eelgrass meadows is enhanced in numbers, species, and standing crop compared to unvegetated soft bottom habitat. Infaunal and epifaunal invertebrate studies conducted in Mission Bay, Sunset Bay and Huntington Harbour eelgrass meadows suggest vegetated bay sediments support a higher diversity of invertebrates compared to unvegetated bay sediments because of the added structure and habitat (MBC Applied Environmental Sciences, 1986). Ninety-seven species of epifauna (plants and invertebrates living on the blades and shoots of eelgrass) were collected from in Mission Bay, Sunset Bay, and Huntington Harbour. Community composition and abundances were dominated by crustaceans (39 species), polychaete worms (23 species) and mollusks (13 species). Other common epifaunal invertebrates included nemertean worms, ectoprocts, hydrozoans, nematodes, and ascidians. The benthic community living amongst the root-rhizome mass included 216 species of invertebrates, dominated in richness and abundance by 87 species of polychaete worms, 63 species of crustaceans, 28 species of clams, and 17 species of snails. Dominant organisms in both the epifauna and infaunal communities were species that occur commonly throughout embayments of Southern California.

2.3.11 Nutrients and Macroalgae

Relationships between nutrients and macroalgae abundances and species compositions have been examined in Upper Newport Bay (SCCWRP, 2003; County of Orange, 2003; County of Orange, 2004; County of Orange, 2005). Findings of these studies indicate that nitrate, rather than organic nitrogen is the most common and most bioavailable nitrogen source. Between 1996 and 2003, the incidence of nuisance algal blooms in the Upper Bay diminished (County of Orange, 2003). In addition, algal biomass decreased along a gradient between San Diego Creek and the Pacific Coast Highway Bridge. The decline in nuisance seaweeds in Upper Newport Bay was similar to those found for all kinds of algae when the limiting nutrient(s) are reduced. The most obvious explanation for the reductions in seaweeds in Newport Bay was the reduction in nitrate entering from San Diego Creek.

Eelgrass competes with macroalgae for space and sunlight, and seasonal blooms of green algae can blanket eelgrass beds (R. Ware, pers. observation). Such events can contribute to year-to-year variations in eelgrass abundance throughout Newport Bay. In areas of poor water circulation where tidal residence times are high, green algae is abundant; in other areas, the red algae (*Acrosorium*), particularly in mid-bay (Harbor Island) and Mariner's Mile areas compete with eelgrass for space and light. The combination of poor water circulation, warm water temperatures, and high algal productivity in areas like Newport Shores and West Newport Bay likely affect the ability of eelgrass to colonize these areas. However, observed water quality improvements in the Newport Bay watershed, like the reduction in nitrates (County of Orange, 2003) over the long term, will benefit eelgrass by reducing competition and shading.

2.3.12 Invasive Algae

Invasive algae (Figure 4) has a potential to cause ecosystem-level impacts in Newport Bay and nearshore systems due to its extreme ability to out-compete other algae and seagrasses. *Caulerpa taxifolia* grows as a dense smothering blanket, covering and killing all native aquatic vegetation in its path when introduced in a non-native marine habitat. Fish, invertebrates, marine mammals, and sea birds that are dependent on native marine vegetation are displaced or die off from the areas where they once thrived. It is a tropical/subtropical species that is used in aquariums. It was introduced into Southern California in 2000 (Agua Hedionda Lagoon) and (Huntington Harbour) by way of individuals likely dumping their aquaria waters into storm drains, or directly into the lagoons. While outbreaks have been contained, the Water Resources Board, through the National Marine Fisheries Service and the California Department of Fish and Game require that when projects that have potential to spread this species through dredging, and bottom-disturbing activities preconstruction surveys must be conducted to determine if this species is presence using standard agency-approved protocols and by National Marine Fisheries Service / California Department of Fish and Game Certified Field Surveyors.

Source: NMFS
Figure 4. Invasive Algae, *Caulerpa taxifolia*

2.3.13 Effects of Bottom Disturbances on Eelgrass

Eelgrass is susceptible to physical damage from activities that disturb the seafloor. Dredging will remove all vegetation and change bottom depth and sediment characteristics. Deployment of anchors and anchor chains will remove eelgrass vegetation and create furrows within eelgrass beds, as will damage from vessel propellers. Single-point mooring anchor systems can "crop and thin" eelgrass within a defined radius around the anchor chain as ebb and flood tides change the position of the mooring. Some bottom disturbances are temporary while others will result in a sustained, long-term loss of eelgrass, particularly where depth and light requirements for eelgrass are permanently altered.

2.3.14 Historical Range of Eelgrass in Newport Bay

Pre-1900s – It is difficult to asses whether eelgrass was present in Newport Bay prior to the time of the development of Newport Harbor. However, there are indications that eelgrass was present in the vicinity of Newport Bay dating back to at least 600 A.D. (Weide, 1981) as evidenced by the presence of eelgrass in local midden (refuse areas) remains along the shoreline of what is now Upper Newport Bay (Attachment 1). Prior to the mid 1800s, "Newport Harbor", or "Lower Newport Bay" did not exist and the coastline was an open coastal sandy beach and rocky shoreline. Eelgrass was only present in what is now referred to as "Upper Newport Bay". Following the formation of a sand spit that formed the Balboa Peninsula in the mid to late 1800s, quiet water conditions in Newport Lagoon were likely conducive for eelgrass growth and establishment.

Recent History – In Upper Newport Bay, eelgrass was reported to be present in the 1950s and 1960s, although not abundantly, from the Coast Highway Bridge to the southern tip of Upper Island near Big Canyon (Barnard and Reish, 1959; State Water Quality Control Board, 1965; Stevenson and Emery, 1958; Posjepal, 1969; Hardy, 1970; Allen, 1976). The bulk of eelgrass was located in the main channel on the west side of the Bayside (DeAnza) Peninsula to the entrance to the Dunes Aquatic Park. The estimated amount of eelgrass in the Upper Bay was estimated to be approximately 8 acres (Posjepal, 1969). See Attachment 1 which illustrates where eelgrass was located in the Upper Bay. Comparatively, in 2003/2004, the mapped area of eelgrass in the same vicinity was 1.2 acres and in 2006/2007, the mapped area of eelgrass diminished to 0.001 acre (CRM Inc., 2005 and 2008).

Stephenson and Emery's work, conducted in 1950, indicated that eelgrass was "confined to rather deep, -4 ft channels with mud bottoms and to narrow fringelike patches along the main channel. In Newport Lagoon (the future Newport Harbor), almost continuous expanses of this eelgrass line the deepened channels. In the main channel, with high velocity, the bottom is swept clean of mud, leaving coarse sand and shell. Sparse colonies are found where mud is either beneath the shelly bottom or in small hollows of the channel." Stephenson and Emory (1958, page 35). A California Department of Fish and Game survey of Lower Newport Bay, conducted in 1951 (CDFG, 1953) found eelgrass fragments in several locations: the south side of Balboa Island, the southeast corner of Balboa Island, within the Balboa Channel, the northwest side of Balboa Channel near Harbor Island, two locations along Mariner's Mile, off of the Kerckhoff Marine Laboratory in the entrance channel, and on the east Balboa Peninsula. Allen (1976) found dense eelgrass beds in Newport Harbor off of Bayside Drive and in the entrance channel during 1974 and 1975 while conducting fish studies throughout Newport Bay. Locations of all of the sites where eelgrass was reported present pre-1976 are shown in Attachment 1.

Eelgrass beds all but disappeared in Newport Bay between the late 1960s and the mid 1970s. Although the reason for its disappearance was never conclusively determined, increased siltation, higher turbidity, dredging, and the effects of destructive floods in 1969 likely contributed to the disappearance of eelgrass.

Eelgrass transplants conducted along the DeAnza Peninsula did not survive in 1984 (Ware, 1993). A small subtidal eelgrass bed however, was located near the Castaways Site at a depth of -5 ft MLLW in 1990 and 1992 (Ware, pers. obs). Eelgrass surveys conducted in Upper Newport Bay channels between Coast Highway Bridge and Jamboree Road during December 1997 and January 1998 immediately prior to Upper Bay dredging failed to locate any surviving eelgrass beds (Coastal Resources Management, 1998). Eelgrass acreage in Newport Bay was roughly estimated to be 3 acres in 1993 (Hoffman, pers. comm. in Ware, 1993). In 1999, eelgrass was estimated to cover over 18 acres of shallow underwater habitat (CRM, 2002).

Small patches of eelgrass were located in the Dunes Marina facing Shellmaker Island during predredge surveys in December 2004 (Chambers Group, Inc., 2005). No eelgrass was observed in Upper Bay during extensive surveys conducted prior to the Upper Newport Bay Restoration Project (MBC Applied Environmental Sciences, 2004) or within the Dunes Marina or Aquatic Park in October 2007 (Chambers Group, 2007; CRM, Inc., 2007).

Bay-wide mapping surveys were conducted in 2003–2004 and again in 2006–2008 (CRM Inc., 2005, CRM Inc., 2008; CRM in progress) using diving biologists and GPS technology to map the distribution of shallow water eelgrass between bulkhead-to-pierhead lines at depths to -10 ft MLLW. During 2003, the National Marine Fisheries Service mapped eelgrass in the deeper portions of the entrance channel and Corona del Mar Reach using a single beam acoustic sonar unit. In 2008, CRM, Inc. mapped eelgrass in the deeper portions of the same areas at depths between -10 and -25 ft MLLW using sidescan sonar technology. The distribution of eelgrass in the Bay during these surveys is summarized on Figure 5, and presented by region on Figures 6–13. These results suggest that eelgrass acreage increased from approximately 3 acres in 1993 to over 100 acres in 2003–2004, and then decreased to 70.7 acres in 2006–2008. Variation can be high over the short term (two to three years) depending on storm events and other extrinsic factors.

Areas of greatest eelgrass abundance in Newport Bay during 2003–2004 included the harbor entrance channel, and the shorelines of Corona del Mar, Balboa Island, Harbor Island / Beacon Bay, Balboa Channel yacht and marina basins, and the channels that surrounded Linda Isle (Areas 1-4). Upper Newport Bay (Area 8) had a significant eelgrass meadow around the southern one-half of the DeAnza/Bayside marsh peninsula and nearby the Castaways Site on the west side of the Channel. Eelgrass was substantially less abundant in West Newport Bay (Areas 5, 6, and 7) along the shoreline of Mariner's Mile, Lido Isle, the Balboa Peninsula shoreline west of Bay Island.

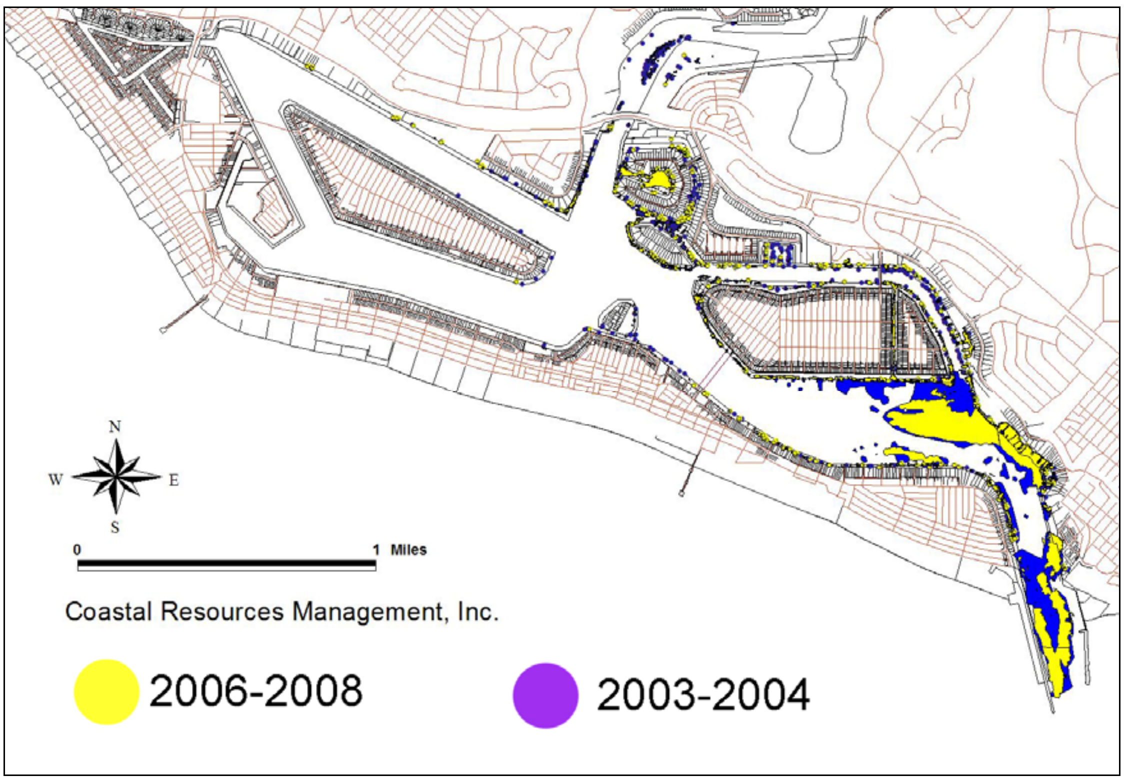


Figure 5. Newport Bay Eelgrass Distribution 2003–2004 and 2006–2007 Surveys Maximum Distribution

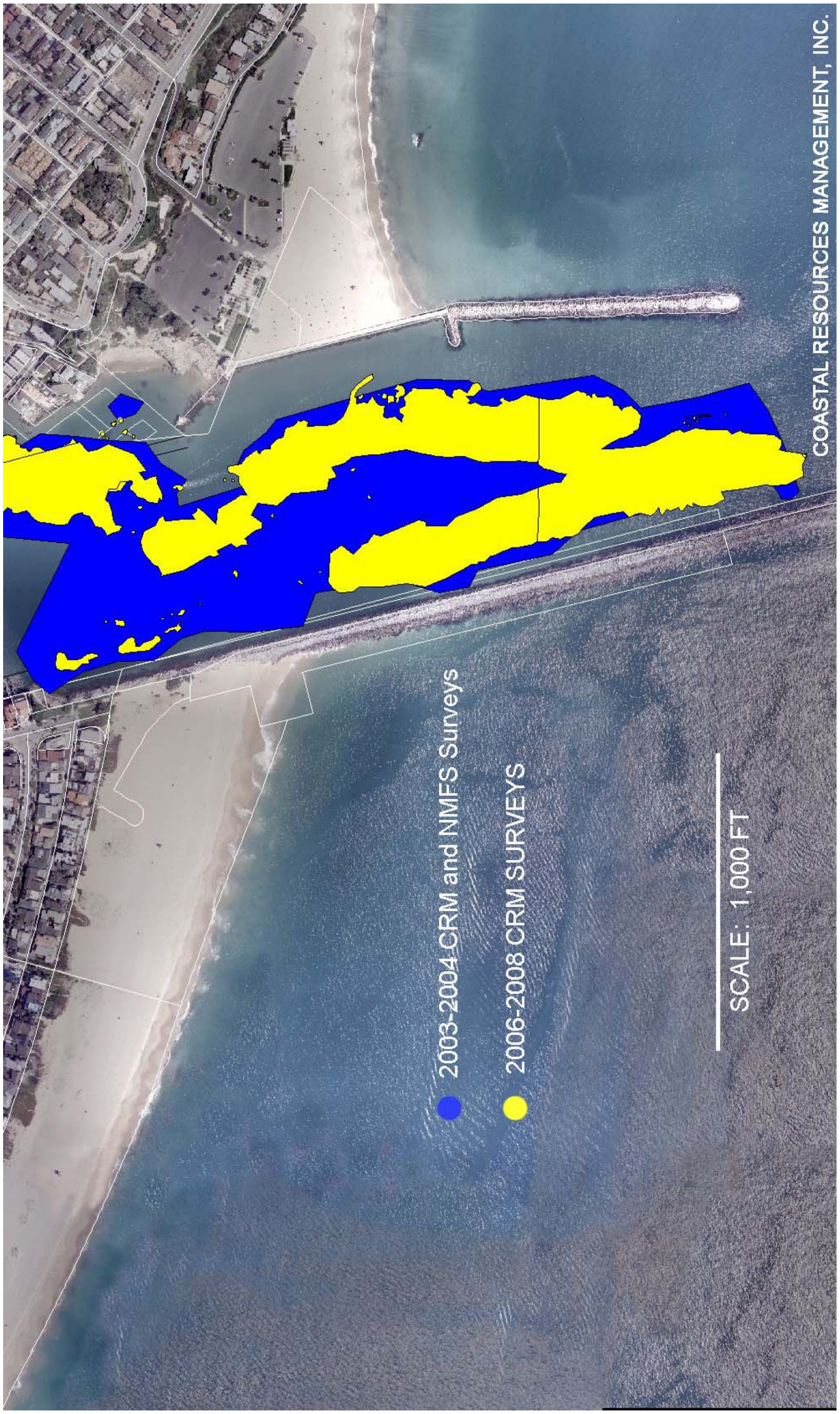


Figure 6. Area 1, Eelgrass Habitat, Entrance Channel

Figure 7. Area 2, Eelgrass Habitat, Corona Del Mar Reach

Figure 8. Area 3, Eelgrass Habitat, Balboa Island

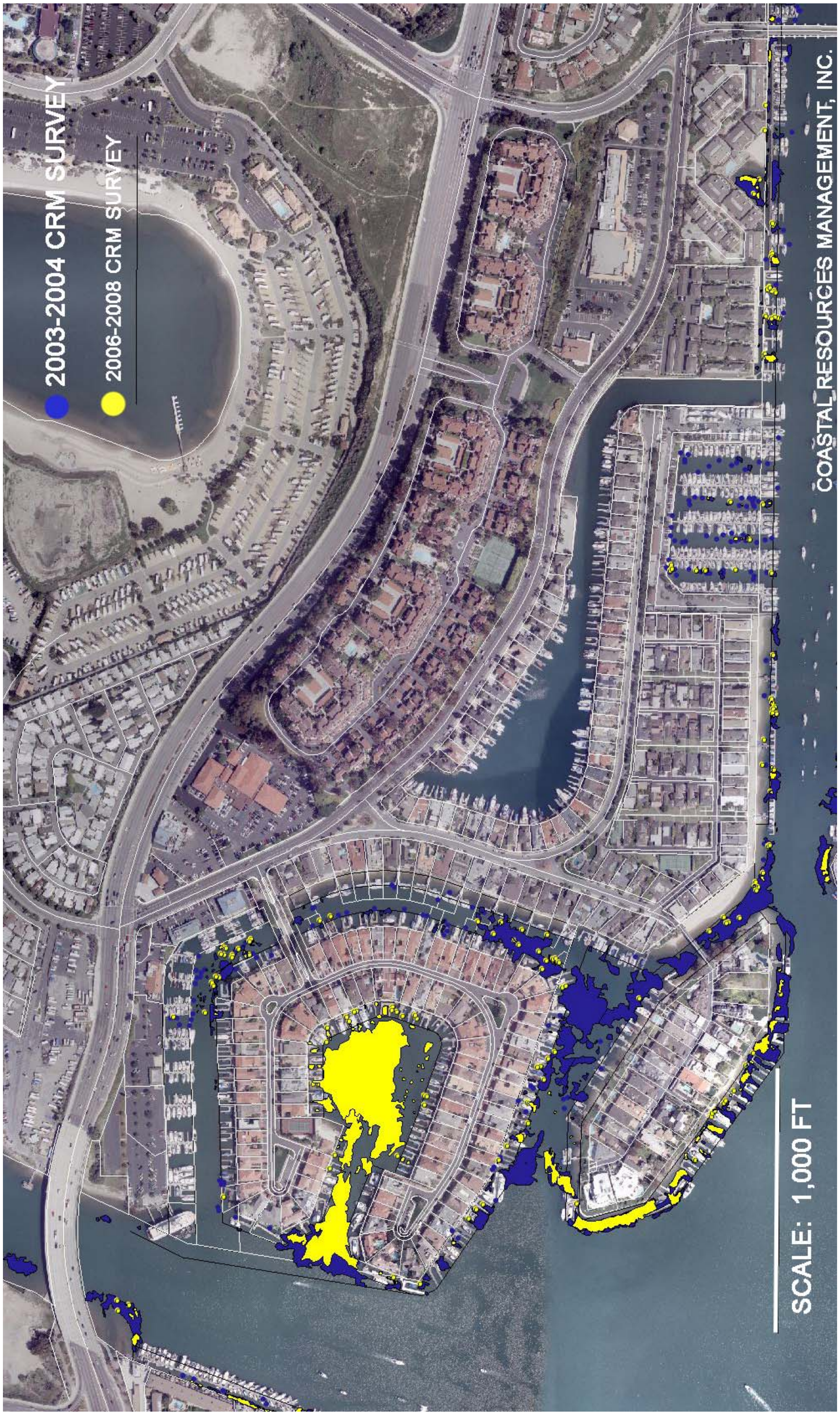


Figure 9. Area 4, Eelgrass Habitat, North Harbor

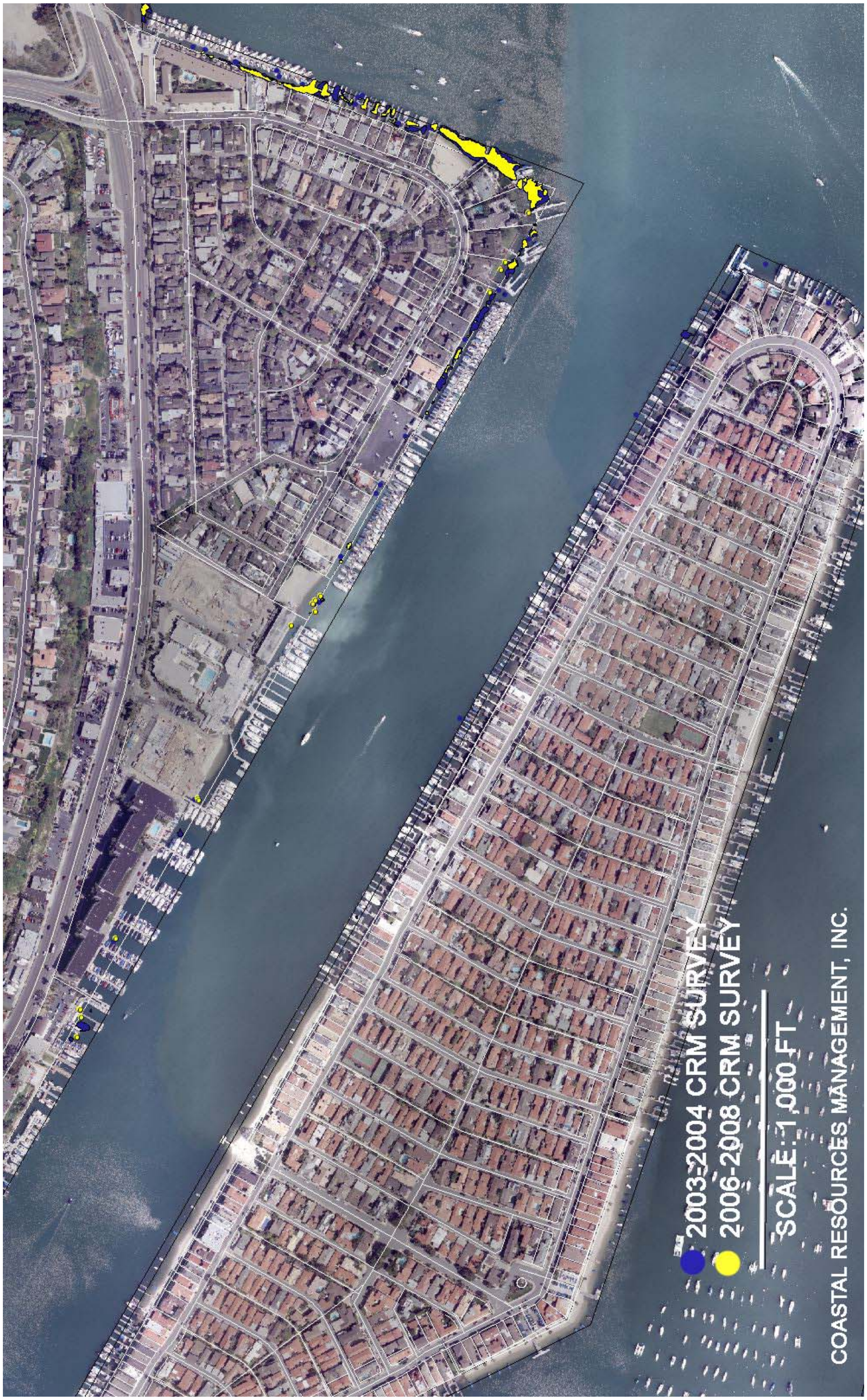


Figure 10. Area 5, Eelgrass Habitat, Northwest Harbor

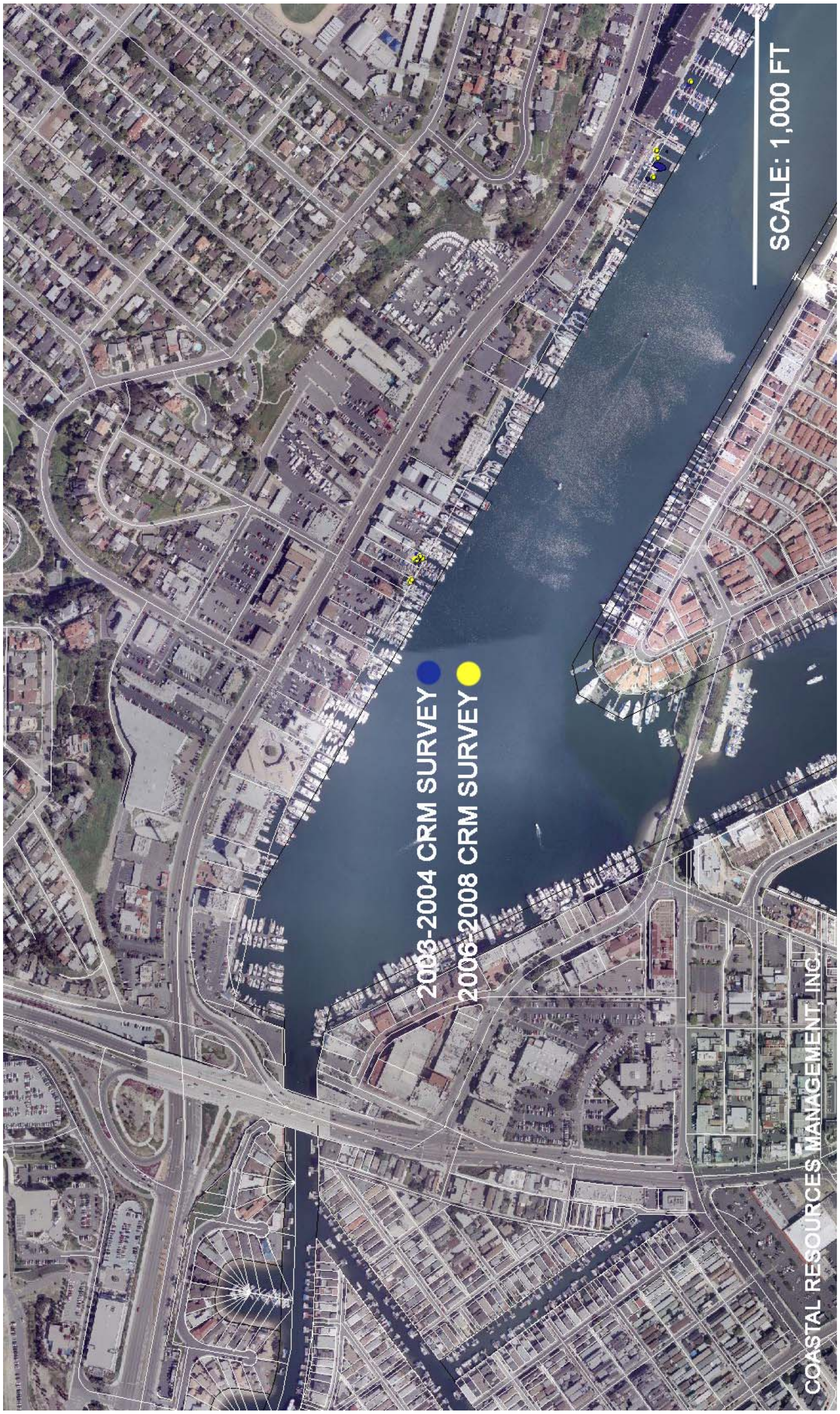


Figure 11. Area 6, Eelgrass Habitat, Northwest Newport Harbor

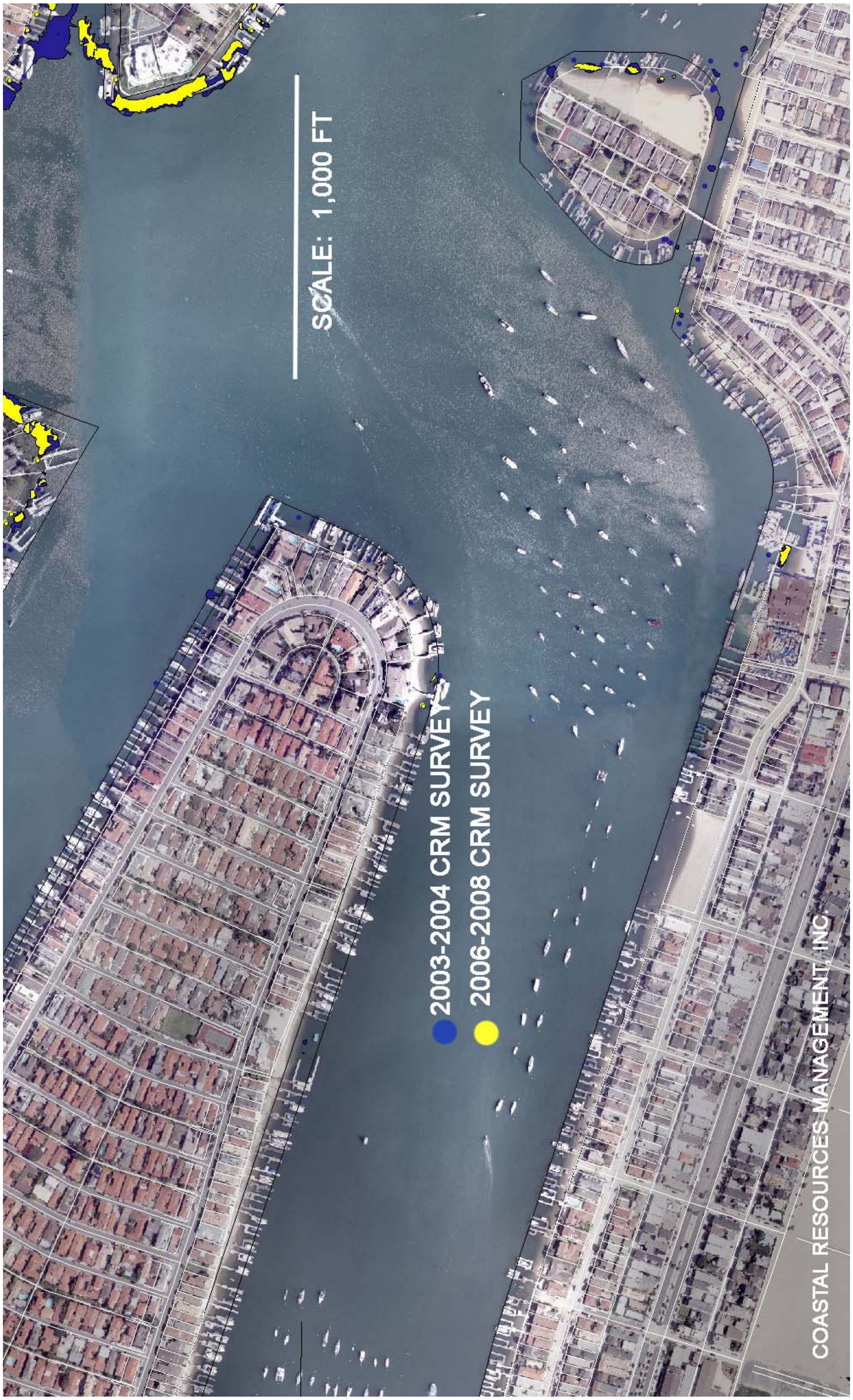


Figure 12. Area 7, Eelgrass Habitat, Soutwest Newport Harbor

Figure 13. Area 8, Eelgrass Habitat, Upper Newport Bay. Note: Eelgrass Patches in the Newport Dunes Marina were mapped by Chambers Consultants (2005)

In 2003–2004, 30.4 acres of shallow water eelgrass were mapped within the bulkhead-to-pier head lines (CRM, Inc., 2005) and 93 acres in the deeper navigational channels between Corona del Mar and Balboa Island (NMFS unpublished data). Some of the CRM and NMFS mapping areas overlapped in the main channel, so the total amount in the bay was less than the 124 acres when the data for the two surveys were summed.

The increase in eelgrass acreage in Newport Bay since 1993 may be the result of several factors: an improvement in water clarity, highly favorable growing conditions during prolonged dry weather years (i.e., La Niña years of low rainfall and low concentration of suspended sediments), better management of dredge and fill projects in the last decade, increased environmental awareness of the importance of eelgrass, and more systematic, repetitive methods of mapping eelgrass vegetation (CRM, Inc., 2005).

CRM conducted shallow water eelgrass surveys again in 2006–2007 (CRM, Inc., 2008) and mapped 23.1 acres-a decline of 7.4 acres within a three-year period (Table 1). Losses occurred primarily in Upper Bay (Area 8), in the channels surrounding Linda Isle and Harbor Island, and along the north shoreline of Balboa Island (Area 4). While the overall loss in Newport Harbor was 24% compared to 2003–2004, losses in these particular regions ranged from 31% and 100% compared to 2003–2004. Exceptions to the eelgrass loss patterns included both the inlet of Linda Isle and the Grand Canal, both of which exhibited increases rather than losses. Both of these areas are shallow, with relatively narrow openings.

CRM, Inc., using sidescan sonar methods, surveyed the deeper navigational channels originally surveyed by NMFS (2003) and mapped 47.6 acres of eelgrass at depths between -10 and -25 ft MLLW in Areas 1-3 (Figures 6, 7, and 8). This represents a decrease of 46.1 acres compared to the NMFS 2003 survey results. This may be reflective of differences in survey methods used and data interpretation (single beam sonar vs sidescan sonar) or an actual loss of eelgrass. Two large sections of the navigation channel contained eelgrass: the harbor entrance channel and the main channel between Corona del Mar and Balboa Island. However, the recent CRM surveys, using sidescan sonar technology, were ground-truthed by divers and remote video methods that provided a high degree of confidence in the data and the interpretation of the sidescan sonar records.

The distribution of eelgrass appears to be heavily influenced by the amount of time it takes to fully flush the bay based upon tidal flushing rates (Figures 14, 15a and 15b, and 16). Longer periods between complete tidal flushing reduces water quality by increasing water temperatures, lowering dissolved oxygen, and increasing the length of time that suspended sediments prevent light from illuminating the seafloor. The reduction in eelgrass area observed during the 2006–2007 survey was likely related to overlapping factors: tidal flushing rates combined with region-wide rainfall and runoff events that occurred during late 2004 and Winter 2005 period, which was one of the wettest rainfall years on record. In addition, heavy plankton blooms were present in the harbor during Spring and Summer 2005 (R. Ware, pers. observations). Eelgrass losses were associated with increased suspended material that remained in the harbor for long periods following extremely heavy rainfall in areas where tidal flushing rates exceeded six to eight days (Figure 16) and secondly, prolonged reduced light levels due to heavy plankton blooms.

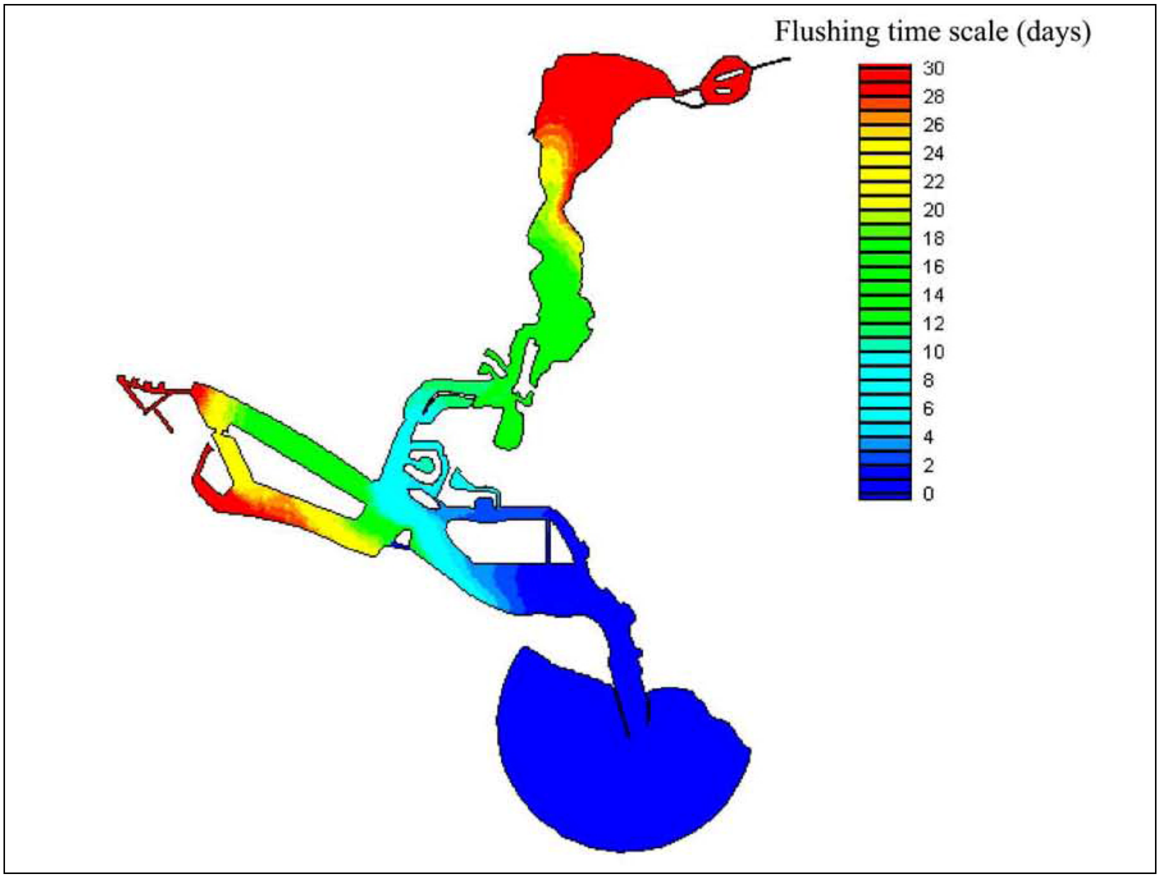
The pattern of eelgrass habitat loss around Linda Isle and Harbor Island may also suggest that events related to Upper Bay restoration activities such as dredge-scow and tug movement through Newport Harbor may have created higher than normal suspended sediment loads in areas of low tidal flushing rates over the last few years (Figure 14). While in the long run, Upper Newport Bay restoration activities will benefit eelgrass. In the short term however, secondary effects related to dredging have a potential for limiting eelgrass recovery in Lower Bay and near the PCH Bridge in Upper Newport Bay.

The one exception where eelgrass has not receded is Linda Isle basin where eelgrass has actually increased in acreage compared to 2003. This area may have been excluded from effects of rainfall events and higher turbidity in 2004–2005, and increased turbidity from dredge scow movement because of the physiographic setting of the area; the entrance to the basin is relatively narrow, it has a single entrance opening, and the tidal current flows from Upper Newport Bay pass perpendicular to the opening to the basin. It is atypical compared to other areas of high eelgrass abundance because the tidal residence time in Linda Isle basin is more typical of areas that do not support extensive eelgrass beds, and sediments are extremely high in silt (96%) compared to other areas that support eelgrass.

Table 1. Eelgrass Abundance in Newport Bay, 2003–2004 and 2006–2007 Surveys

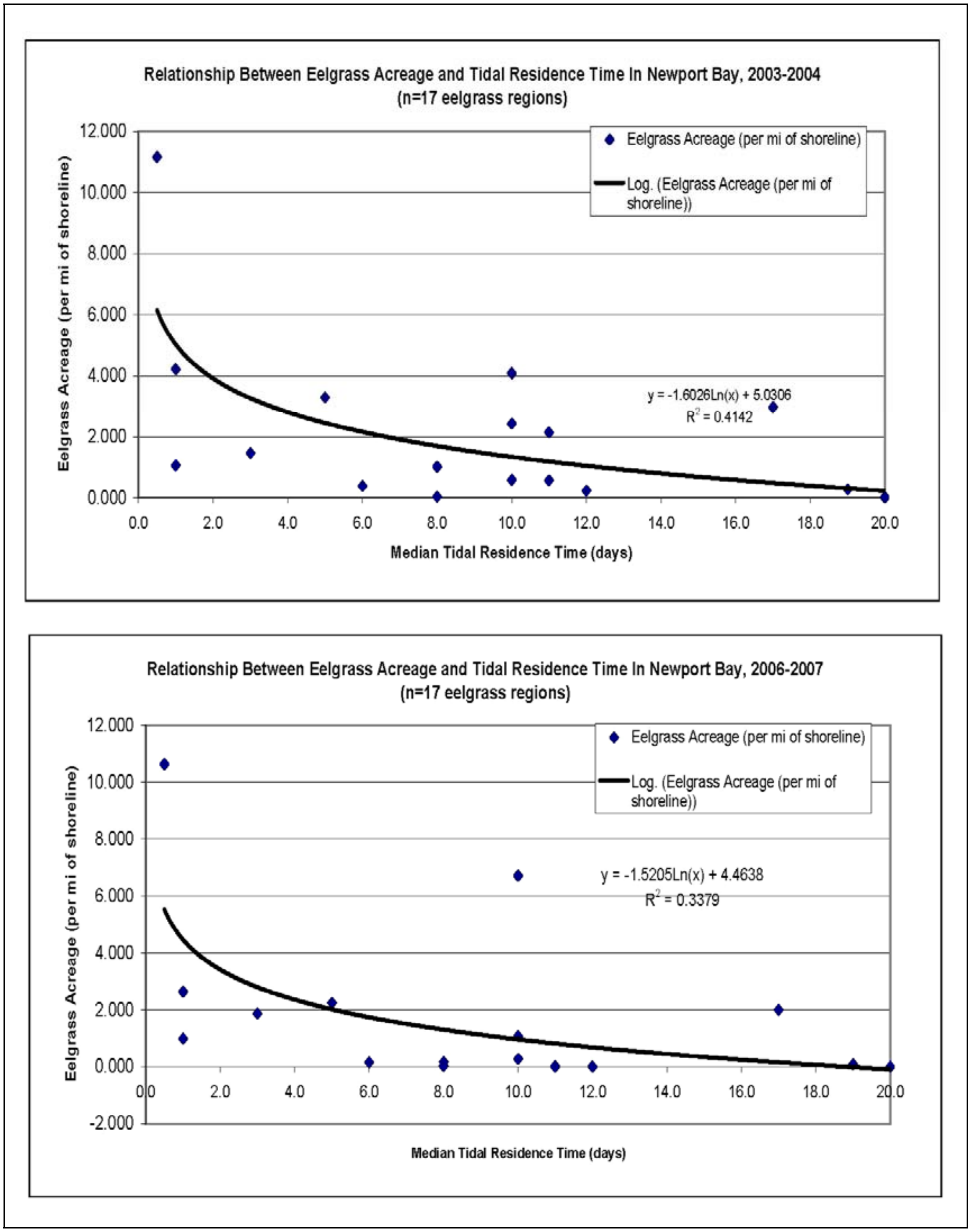
Section of Newport Bay	2003-2004 (acres)	2006-2007 (acres)	Mean (acres)	Difference (acres)	% Difference	Shoreline Length (Miles)	Mean Acres/Linear Mile
Corona del Mar/Bayside Drive to OCHD	9.521	9.075	9.298	-0.446	-4.7	0.85	10.90
Balboa Channel Yacht Basins	2.469	1.539	2.004	-0.93	-37.7	0.58	1.02
Balboa Peninsula-East of Bay Island	1.672	1.557	1.615	-0.115	-6.9	1.58	0.03
Grand Canal	0.898	1.143	1.021	0.245	27.3	0.61	0.59
Balboa and Collins Islands	6.686	4.554	5.620	-2.132	-31.9	2.03	3.43
Bay Island	0.132	0.051	0.092	-0.081	-61.4	0.34	0.12
Balboa Peninsula-West of Bay Island	0.034	0.03	0.032	-0.004	-11.8	1.09	0.18
North Balboa Channel and Yacht Basins	0.698	0.115	0.407	-0.583	-83.5	0.69	1.35
Harbor Island	2.721	0.712	1.717	-2.009	-73.8	0.67	2.77
Linda Isle (outer channels)	2.916	0.328	1.622	-2.588	-88.8	1.20	0.27
Linda Isle (Inner basin)	0.281	3.218	1.750	2.937	1045.2	0.48	1.67
DeAnza/Bayside Peninsula (inner side)	0.209	0.009	0.109	-0.2	-95.7	0.37	1.07
DeAnza/Bayside Peninsula (Outer)	0.792	0	0.396	-0.792	-100.0	0.37	3.64
Castaways to Dover Shores	0.132	0	0.066	-0.132	-100.0	0.56	2.48
Bayshores	0.991	0.664	0.828	-0.327	-33.0	0.33	2.58
Mariner's Mile	0.234	0.066	0.150	-0.168	-71.8	0.84	0.30
Lido Isle	0.025	0.004	0.015	-0.021	-84.0	2.23	0.01
All Regions	30.411	23.065	26.738	-7.346	-24.2	14.82	1.80

Source: CRM, Inc.



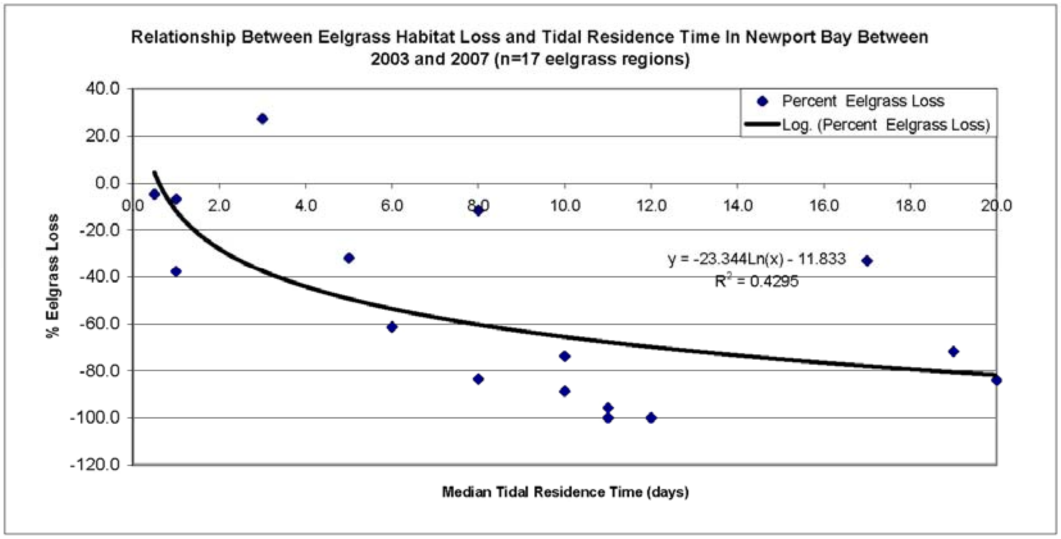
Source: Ying Poon, Everest International Consultants

Figure 14. Tidal Flushing Rates in Newport Bay



Source: CRM, Inc., 2008

Figure 15. Relationships between Eelgrass Acreage and Tidal Residence Times in Newport Bay, 2003–2004 and 2006–2007



Source: CRM, Inc., 2008

Figure 16. Relationships between Eelgrass Habitat Loss and Tidal Residence Times in Newport Bay, 2003–2007

Based upon these studies, eelgrass distribution in Newport Harbor can be divided into three zones: a Stable Eelgrass Zone that includes areas where tidal flushing is between approximately zero and six days; a Transitional Zone where eelgrass acreage is susceptible to large-scale variability and tidal flushing is approximately seven to 14 days; and an Unvegetated Eelgrass Zone where tidal flushing ranges between 14 days and 30 days and the amount of eelgrass present is either insignificant or lacking.

Eelgrass within the Stable Eelgrass Zone provides longer-term critical habitat for more organisms than within the Transitional Eelgrass Zone, where organisms are highly susceptible to short-term and long-term losses of vegetation. Stable Eelgrass Zone shallow water acreage based on the average of the two bay-wide eelgrass habitat mapping surveys is approximately 20 acres and 47 acres of deeper channel eelgrass (based on the 2008 deeper channel surveys. Shallow water Transitional Eelgrass Zone habitat, on the other hand, accounts for approximately 10 acres of eelgrass and no deeper channel eelgrass habitat exists in the Transitional Eelgrass Zone.

Eelgrass Turion Density – A turion is an above ground unit of eelgrass growth that consists of an eelgrass shoot and associated eelgrass blades. Eelgrass density refers to the number of turion units per area of bayfloor. Turion density can be highly variable as a result of water temperature, water currents and tidal exchange rates, sediment characteristics, light availability, and water depth. A combination of low and high density canopy, and open patches of unvegetated sediment may contribute to a greater diversity of organisms and a more complex ecological system.

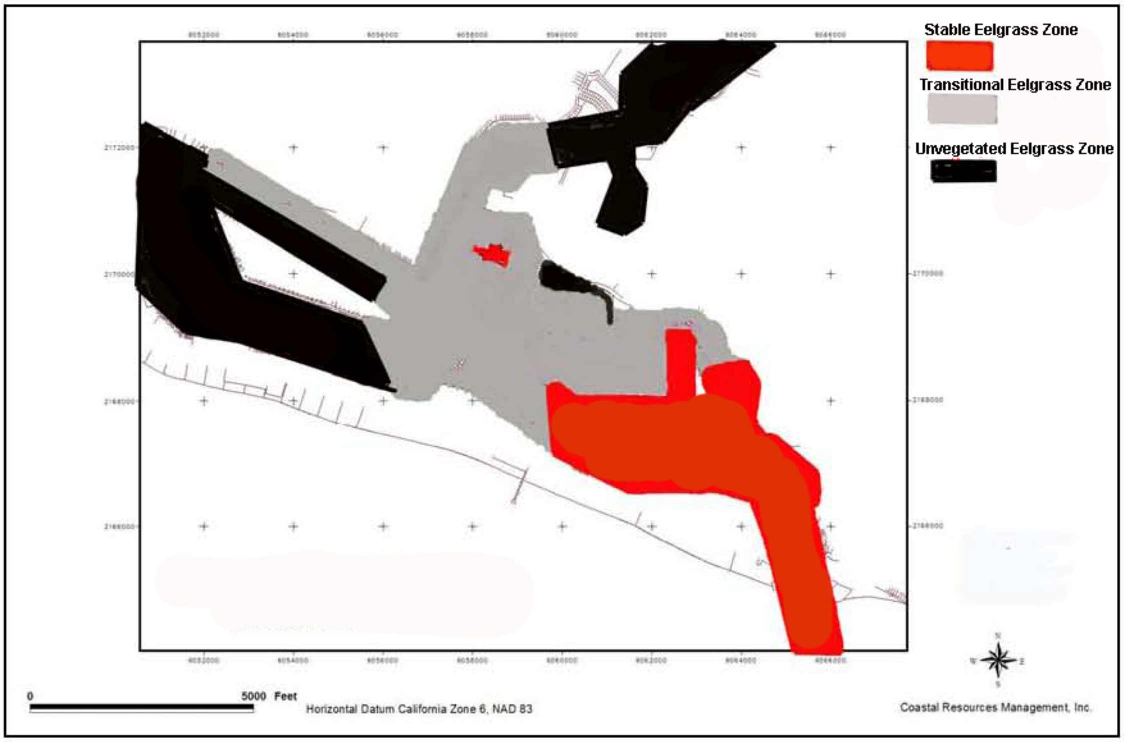


Figure 17. Eelgrass Habitat Zones in Newport Bay

For example, open, unvegetated areas in eelgrass beds are frequented by demersal (bottom) fishes such as sand bass, staghorn sculpin, turbot, California halibut, and round stingray. Some disrupt the bottom sediments (bioturbation) and create their own open habitat in eelgrass beds as they forage in the muds (Merkel, 1990). Dense, long-bladed canopy will provide a greater degree of protection and shelter for cryptic, resident species (canopy-associated pipefish and kelpfish), and shelter or foraging habitat for transients (surfperch and topsmelt).

Mean turion density in Newport Bay eelgrass meadows during late Spring to Summer 2004 period was 231.2 turions per sq m (n=600 replicates) (CRM Inc., 2005). By sampling area, turion density ranged between 102.3 (Orange Coast College Boat Basin) to 323.4 per sq m (Outer DeAnza Peninsula). In most areas of Newport Bay, eelgrass turion density exhibited a significant negative correlation to sampling depth (t=2.8, 12 deg freedom, $r^2 = 0.72$). While this is true for most areas, deeper areas with better water clarity near the ocean entrance channel support higher density eelgrass beds than regions farther back in the harbor at similar depths (i.e., Lido Yacht Club and the Orange Coast College Boat Basin).

In 2008, Newport Bay eelgrass turion density was 136.1 turions per sq m (n=415 replicates; CRM Inc., in progress), which is 60% of the average density observed in Newport Bay in 2004 and ranged between no eelgrass (where it previously was present) to 234.8 turions per sq m along Corona del Mar shoreline. Substantial density decreases occurred at stations in the Transitional Eelgrass Zone; five of the sampling stations in 2004 lacked eelgrass in 2008 (two in Upper Newport Bay, at Lido Yacht Club, and within the Orange Coast College boat basin).

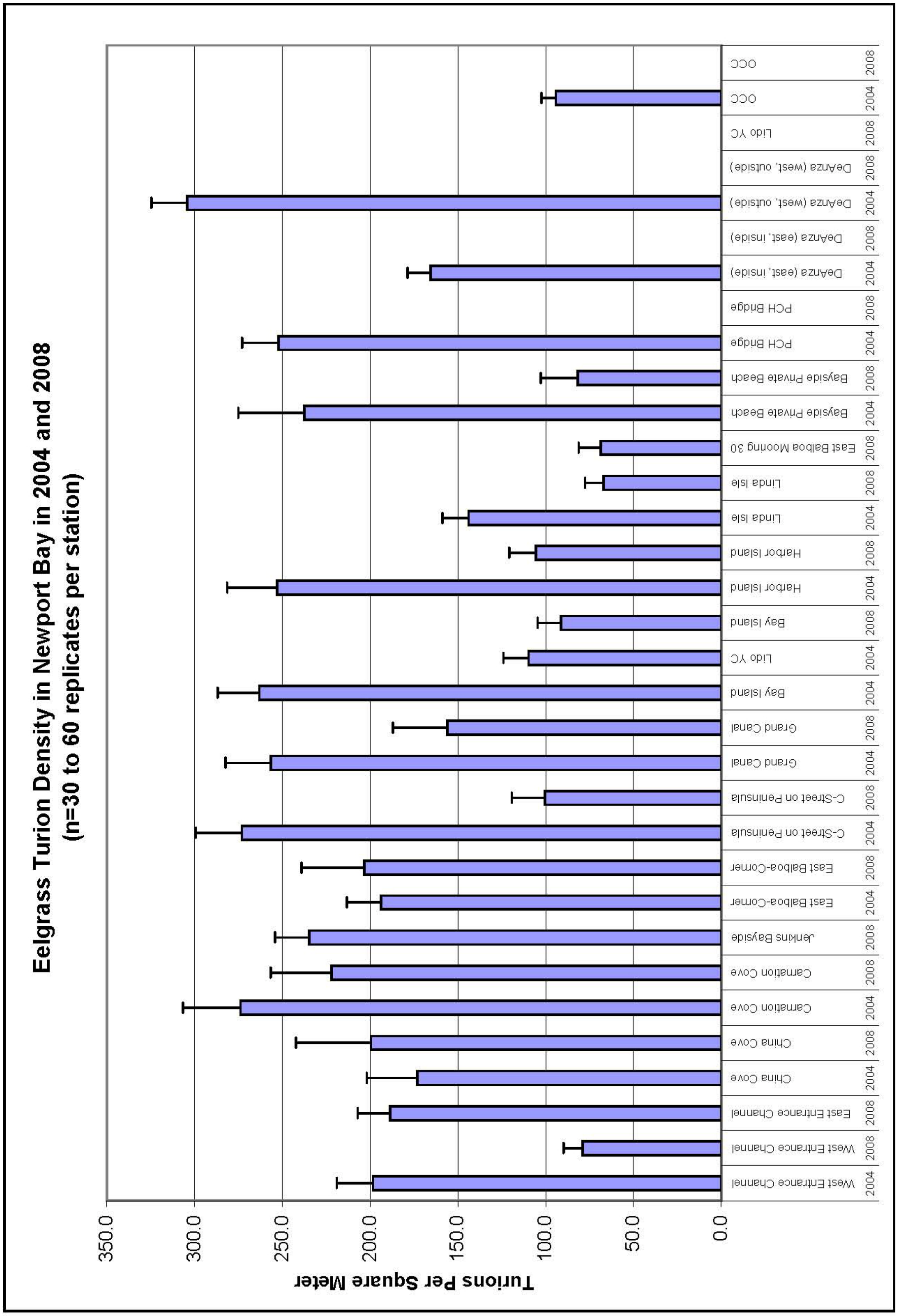


Figure 18. Eelgrass Turion Density in Newport Bay, 2004–2008

2.4 Eelgrass Regulatory Overview

Environmental legislation under the National Environmental Policy Act (NEPA) and State of California Environmental Quality Act (CEQA) dictates that project designs for coastal projects (1) make all possible attempts to avoid impacts to eelgrass, (2) minimize the degree or magnitude of impacts, (3) rectify, or compensate for unavoidable eelgrass habitat losses by restoring soft bottom habitat with eelgrass using transplant techniques, and (4) reduce or eliminate impacts to eelgrass over time by preservation and maintaining eelgrass over the life of the project. Eelgrass is considered a protected resource by California Department of Fish and Game, U.S. Fish and Wildlife Service, and the National Marine Fisheries Service although it does not have a formal listing as a state or federal rare, sensitive, endangered, or candidate species.

2.4.1 Clean Water Act

Eelgrass, as a vegetated shallow water habitat, is protected under the Clean Water Act, 1972 (as amended), section 404(b)(1), "Guidelines for Specification of Disposal Sites for Dredged or Fill Material", subpart E, "Potential Impacts on Special Aquatic Sites." This area includes sanctuaries and refuges, wetlands, mudflats, vegetated shallows, coral reefs, riffle, and pool complexes.

2.4.2 Magnuson–Stevens Fishery Management and Conservation Act (FR 62, 244, December 19, 1997 – Essential Fish Habitat and Habitats of Particular Concern

Newport Harbor and Upper Newport Bay are estuarine and eelgrass habitats, which are considered habitat areas of particular concern (HAPC) for various federally managed fish species within Coastal Pelagic (i.e., northern anchovy) and Pacific Groundfish Fisheries Management Plans (FMP), (i.e., rockfishes) under Essential Fish Habitat (EFH) provisions of the 1996 amendments to the Magnuson–Stevens Fishery Management and Conservation Act (FR 62, 244, December 19, 1997).

EFH is defined as "those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity". An adverse effect is "any impact which reduces the quality and/or quantity of EFH." Adverse effects may include direct or indirect physical, chemical, or biological alterations of the waters or substrate and loss of, or injury to benthic organisms, prey species, and their habitat, and other ecosystem components. Adverse effects may be sites specific or habitat-wide impacts, including individual, cumulative, or synergistic consequences of actions (50 CFR 600.910(a)).

HAPC are described in the regulations as subsets of EFH which are rare, particularly susceptible to human induced degradation, especially ecologically important, or located in an environmentally stressed area. Designated HAPC, including eelgrass, are not afforded any additional regulatory protection under the Magnuson–Stevens Fishery Conservation and Management Act (1997). However, federally permitted projects with potential adverse impacts to HAPC are more carefully scrutinized during the consultation process (National Marine Fisheries Service, 2008).

2.4.3 Southern California Eelgrass Mitigation Policy

Mitigation for impacts to eelgrass bed vegetation and potential eelgrass habitat is addressed in the *Southern California Eelgrass Mitigation Policy* (NMFS, 1991 as amended, Revision 11). This document provides the current standards for all mitigation projects and includes information regarding habitat replacement ratios, timing and methods for eelgrass habitat mapping surveys, eelgrass transplants, monitoring and maintenance, and success criteria. Eelgrass management is on a project-by-project basis, so that individual homeowners and applicants are responsible for implementing surveys, assessing project impacts, conducting transplants, and monitoring transplants for a five-year period. This policy is described in more detail in Section 4.1.1.

2.4.4 California Department of Fish and Game Regulations. 2008 Department of Fish and Game Ocean Fishing Regulations. Section 4 Ocean Fishing

30.00. Kelp General – (a) Except as provided in this section and in Section 30.10 there is no closed season, closed hours or minimum size limit for any species of marine aquatic plant. The daily bag limit on all marine aquatic plants for which the take is authorized, except as provided in Section 28.60, is 10 pounds wet weight in the aggregate. (b) Marine aquatic plants may not be cut or harvested in state marine reserves. Regulations within state marine conservation areas and state marine parks may prohibit cutting or harvesting of marine aquatic plants per subsection 632(b). 30.10. Prohibited Species. No eelgrass (*Zostera)*, surf grass *(Phyllospadix*), or sea palm (*Postelsia*) may be cut or disturbed.

2.4.5 California Code of Regulations, Title 14, 650. Natural Resources. Division 1. Fish and Game Commission – Department of Fish and Game. Subdivision 3, General Regulations. Chapter 1. Collecting Permits

(a) General – Except as otherwise provided, it is unlawful to take or possess marine plants, live or dead birds, mammals, fishes, amphibians, or reptiles for scientific, educational, or propagation purposes except as authorized by a permit issued by the department.

2.4.6 City of Newport Beach Local Coastal Plan

The City of Newport Beach has an adopted, Coastal Commission-approved land use plan (LUP). The LUP acknowledges that the need to maintain and develop coastal-dependent uses may result in impacts to eelgrass:

"Dredging and dock and bulkhead construction projects have a potential to impact eelgrass resources within several areas of Newport Bay through direct habitat loss or secondary effects of turbidity or vessel anchor scarring. However, ongoing maintenance of harbor structures and periodic dredging is essential to protect Newport Harbor's value as a commercial and recreational resource. A comprehensive and balanced management plan is necessary to maintain the recreational and commercial uses of the harbor while protecting its natural marine resources…" LUP at 4-40.

To mitigate the potential impacts to eelgrass of dredging and development, the LUP requires the avoidance where possible and restoration where avoidance is not practical:

“Avoid impacts to eelgrass (*Zostera marina*) to the greatest extent possible. Mitigate losses of eelgrass at 1.2 to 1 mitigation ratio and in accordance with the Southern California Eelgrass Mitigation Policy. Encourage the restoration of eelgrass throughout Newport Harbor where feasible.” LUP Policy 4.2.5-1.

3.0 CURRENT CHALLENGES TO ESTABLISHING SUSTAINABLE EELGRASS POPULATIONS IN NEWPORT HARBOR

The most critical challenges to eelgrass populations and their establishment are (1) the presence of availability of suitable intertidal and subtidal soft-bottom habitat (2) maintaining adequate water quality and underwater light conditions to promote eelgrass growth and health and (3) maintaining a balance between the natural resources within Newport Harbor with the uses of Newport Harbor as a viable recreational boat harbor so that the areal cover and health of eelgrass vegetation continues to serve an important function as a habitat for marine life.

These challenges are particularly important because eelgrass mitigation projects cannot be successful unless specific habitat requirements are met for the establishment and growth of eelgrass. In addition, biodiversity associated with eelgrass beds is directly influenced by the conditions that govern eelgrass growth and habitat characteristics. Dredging, bulkheading, and other waterside infrastructure projects affect the abundance and distribution of eelgrass through direct losses (i.e., removal or burial) and secondarily, light-limitations through sediment resuspension and construction of structures that impede light from reaching the bayfloor. Infrastructure projects are undertaken as federal, state, local agency projects, or individual resident's projects that don't qualify under the City's Regional General Permit (RGP) 54 due to the presence of eelgrass within 15 ft of their docks, bulkhead, piers, or beach nourishment projects. If residents do not quality for inclusion in the RGP, they are responsible for individually obtaining the necessary state and federal permits from the regulatory agencies.

4.0 DEVELOPING AN EELGRASS MANAGEMENT PLAN

Current and future harbor infrastructural improvement projects such as maintaining safe navigable waters, the renovation and construction of piers, docks, seawalls, and replenishing the harbor's beaches will affect the distribution and abundance of eelgrass and will require programs to compensate for eelgrass habitat losses. Thus, understanding governing regulations, the constraints for eelgrass success in various regions of the bay, and identifying specific mitigation options for eelgrass losses are important to review.

4.1 Current Guidelines for Conducting Eelgrass Transplants

The Southern California Eelgrass Mitigation Policy (SCEMP) (NMFS, 1991 as amended) is the basis for current eelgrass mitigation throughout the Southern California region.

Eelgrass transplants "shall be considered only after the normal provisions and policies regarding avoidance and minimization, as addressed in the Section 404 Mitigation Memorandum of Agreement between the Corps of Engineers and Environmental Protection Agency, have been pursued to the fullest extent possible prior to the development of any mitigation program. Mitigation will be required for the loss of existing vegetated areas, loss of potential eelgrass habitat, and/or degradation of existing/potential eelgrass habitat as well as for boat docks and/or related work" (NMFS, 1991 as amended).

The policy requires that eelgrass habitat losses be successfully mitigated at a 1.2:1 mitigation-to-impact ratio (i.e., successful mitigation over a period of five years requires an additional 20% more eelgrass habitat than the amount originally impacted by the project). Also, the policy defines the methods by which eelgrass transplants will be conducted, despite the possibility that other, more cost-effective and efficient methods have been developed since the inception of the SCEMP.

The SCEMP does recognize that "There may be circumstances (e.g., climatic events) where flexibility in the application of this Policy is warranted. As a consequence, deviations from the stated Policy may be allowed on a case-by-case basis.

4.1.1 Current Specific Mitigation Success Criteria from the Policy (NMFS 1991 as amended)

Criteria for determination of transplant success shall be based upon a comparison of vegetation coverage (area) and density (turions per square meter) between the **adjusted project impact area** (i.e., original impact area multiplied by 1.2) and **mitigation site(s)**. Extent of vegetated cover is defined as that area where eelgrass is present and where gaps in coverage are less than one meter between individual turion clusters. Density of shoots is defined by the number of turions per area present in representative samples within the original impact area, control or transplant bed. Specific criteria are as follows:

a) The mitigation site shall achieve a minimum of 70% area of eelgrass and 30% density as compared to the adjusted project impact area after the first year.

b) The mitigation site shall achieve a minimum of 85% area of eelgrass and 70% density as compared to the adjusted project impact area after the second year.

c) The mitigation site shall achieve a sustained 100% area of eelgrass bed and at least 85% density as compared to the adjusted project impact area for the third, fourth and fifth years.

Should the required eelgrass transplant fail to meet any of the established criteria, then a Supplementary Transplant Area (STA) shall be constructed, if necessary, and planted. The size of this STA shall be determined by the following formula:

$STA = MTA \times (|A_t + D_t| - |A_c + D_c|)$
MTA = mitigation transplant area.
A_t = transplant deficiency or excess in area of coverage criterion (%).
D_t = transplant deficiency in density criterion (%).
A_c = natural decline in area of control (%).
D_c = natural decline in density of control (%).

The STA formula shall be applied to actions that result in the degradation of habitat (i.e., either loss of areal extent or reduction in density).

Five conditions apply:

1) For years 2–5, an excess of only up to 30% in area of coverage over the stated criterion with a density of at least 60% as compared to the project area may be used to offset any deficiencies in the density criterion.

2) Only excesses in area criterion equal to or less than the deficiencies in density shall be entered into the STA formula.

3) Densities which exceed any of the stated criteria shall not be used to offset any deficiencies in area of coverage.

4) Any required STA must be initiated within 120 days following the monitoring event that identifies a deficiency in meeting the success criteria. Any delays beyond 120 days in the implementation of the STA shall be subject to the penalties as described in Section 8.

5) Annual monitoring will be required of the STA for five years following the implementation and all performance standards apply to the STA.

Eelgrass transplant programs cannot be conducted within areas where eelgrass has occurred in the past or where it currently is present since the transplant would only be considered “habitat enhancement” by National Marine Fisheries Service (Bryant Chesney, NMFS per. com to R. Ware, April, 2007). Therefore, eelgrass transplants for mitigation purposes must be conducted at sites where eelgrass has historically not been present or in areas “created” within Newport Bay by dredging or in-filling of bay habitat to depth ranges and with sediment types that are known to support eelgrass vegetation.

4.1.2 Eelgrass Mitigation Success in Newport Bay

Eelgrass mitigation was initiated in the late 1970s and early 1980s in Newport Bay. These have taken place in the Harbor Entrance Channel for U.S. Army Corps of Engineers dredging projects (Noel Davis, Chambers Consultants, pers. com. with R. Ware, January 2008); on De Anza (Bayside) Peninsula in Upper Newport Bay as mitigation for eelgrass losses in Huntington Harbour (MBC Applied Environmental Sciences, 1987) and for the 2004 U.S. Army Corps of Engineers Harbor Entrance Channel / Balboa Channel Dredge Project (MBC Applied Environmental Sciences, 2004); for a pier and dock project at a private residence on Bayside Drive (Mike Curtis, MBC Applied Environmental Sciences, pers. com. with R. Ware, 1998); and in the Grand Canal on Balboa Island for losses associated with dredging and seawall protection in 1999 (CRM, Inc., 2000). In addition, under a joint program conducted by the City of Newport Beach, the U.S. Army Corps of Engineers, and the County of Orange, a Newport Harbor Eelgrass Pilot Restoration Project was undertaken by Chambers Group, Inc. and CRM, Inc. in August and September 2004 under Section 206 of the Water Resources Development Act (1996). Six sites in Lower and Upper Newport Bay were experimentally transplanted to determine if these sites could be used as eelgrass mitigation banking sites for future federal, city, and county eelgrass mitigation projects. These were undertaken in Transitional Eelgrass Zones of the harbor.

Of the major eelgrass transplant projects conducted in Newport Bay since 1982 only three were successful; all were conducted within the Stable Eelgrass Zone (Figure 16). These included the 1982 entrance channel transplant, the 1998 Bayside Drive (Corona del Mar) transplant, and the 1999 Grand Canal eelgrass transplant. The remaining transplants were successful for less than one year. Because there were no concurrent studies abiotic parameters at the successful or unsuccessful transplant sites, there are no clear indications of the physical, chemical, or biological conditions that were responsible for either success or failure. However, the failure of the City of Newport / County of Orange / ACOE pilot eelgrass transplants was likely attributable to heavy rains in the months following the transplants, extremely warm temperatures during the late-season planting period, and the long tidal residence times that diminish water quality in the areas that were transplanted.

Eelgrass is capable of recovering from habitat disturbances without mitigation measures being implemented. For example, following a dredging project in the Grand Canal during the mid-1980s, eelgrass successfully recolonized the area (R. Ware, pers. com with Robert Hoffman). After dredging the Balboa Channel in 2004, eelgrass was reported to have naturally grown back on the dredged slope (R. Ware, pers. com. with Tom Rossmiller, City of Newport Beach Harbor Resources Department). Alternatively, it is possible that patches of eelgrass were left untouched during the dredging operation.

4.2 Eelgrass Threshold Capacity

Eelgrass threshold capacity can be defined as the acreage of eelgrass within Newport Bay that is sustainable over time taking into account short-term and long-term temporal and spatial variability. The goal of identifying eelgrass threshold capacity is to provide harbor resource managers a tool by which to evaluate appropriate long-term eelgrass mitigation options relative to future maintenance of harbor infrastructure.

Projects such as maintenance dredging, beach nourishment, dock and bulkhead renovation projects that are within bulkhead and pierhead lines are generally accomplished on an incremental basis, account for the majority of harbor infrastructure projects, and have a high potential to affect eelgrass habitat stability on a year-to-year basis in Newport Bay.Based upon the results of bay-wide shallow water habitat mapping surveys between 2003 and 2007 (CRM Inc., 2005 and CRM, Inc.,2008) the "average threshold capacity" (the average amount of eelgrass mapped in the 2003/2004 and 2006/2007 surveys) in Stable Eelgrass Zones was approximately 20.4 acres. This zone exhibited very little variation between surveys (20 acres in 2003/2004 and 21 acres in 2006/2007). Transitional Eelgrass Zones, where eelgrass habitat is more susceptible to temporal and environmental disturbances than Stable Eelgrass Zones, accounted for an average eelgrass threshold capacity of approximately 6.3 acres, with a range between 2.2 (2006/2007) and 10.4 acres (2003/2004).

Eelgrass in the deeper channels of Newport Harbor are susceptible to less frequent episodic dredging impacts but when dredging occurs, the potential for wide-scale damage to dense and large eelgrass meadows is high. Based on the most recent 2008 survey data set, the threshold capacity of eelgrass in the federal navigational channel is approximately 47 acres

These estimates of eelgrass threshold capacity can be refined, over time, with additional data acquired from bay-wide eelgrass distributional studies.

4.3 Recommended Areas in Newport Bay to Create A Sustainable Eelgrass Population (SEP)

While eelgrass occurs throughout many regions of Newport Bay, its structure and function varies widely from region-to-region and from year to year. Mitigation for losses of eelgrass habitat must be focused in areas where suitable habitat requirements are met for size of the habitat, sediment types, depth, and light intensity) and where eelgrass will survive and flourish over the long term.

Based on the historical distribution changes of eelgrass in Newport Bay, on the results of eelgrass mitigation successes and failures, and the realization that the amount of habitat that meet eelgrass establishment and growth criteria in Newport Bay is extremely limited, high priority should be given to maintaining and creating a sustainable eelgrass population (SEP) in the Stable Eelgrass Zone (Figure 17) . The long-term potential for successful eelgrass population sustainability is highest in this zone, where tidal residence times are less relatively short (less than six days), tidal currents are moderate to high, and there is a history of long-term eelgrass sustainability with minimal year-to-year natural variation

Conversely, maintaining sustainable eelgrass populations in the Transitional Zone is difficult. Creating eelgrass populations in this zone increases the risk of failure because this zone is susceptible to large-scale natural variability due to episodic events such as El Nino and the effects of extremely heavy rainfall and runoff (which occurred in 2004 and 2005). And, in these areas where tidal residence times are already decreased, events such as plankton blooms can push the light threshold limits below that which can sustain eelgrass reproduction, growth, and survival. The potential for the highest risk of mitigation failure is within the Unvegetated

Eelgrass Zone where tidal flushing ranges between 14 days and 30 days and where virtually no eelgrass is currently found.

4.4 Development and Implementation of a Long-Term Eelgrass Management Plan

Eelgrass within both the Stable Eelgrass Zone and the Transitional Eelgrass Zone will be continually susceptible to infrastructure improvements within Newport Harbor. Consequently, it is in the interest of the City to develop and implement a long-term Eelgrass Management Plan to maintain and create a sustainable eelgrass population (SEP) where eelgrass populations have the highest potential for long-term survival.

The City of Newport Beach would be responsible for developing, overseeing, and enforcing compliance with the Eelgrass Management Plan, and be responsible for eelgrass surveying, implementing programs to establish eelgrass populations, monitoring the success of the programs, and conducting periodic, baywide eelgrass surveys. Under such a concept, the City would protect and promote a shallow water eelgrass population and as long as the sustainable eelgrass population is above 20 acres, no more than 2 acres of eelgrass impacts would be permitted per year conditioned on compliance with best management practices (BMPs) for avoiding eelgrass disturbance where possible. Should the shallow water eelgrass population drop below 20 acres, increased mitigation measures and decreased allowable annual impacts will be implemented in a phased manner.

The purpose of the BMPs would be three-fold: (1) To avoid and minimize damage to existing eelgrass bed resources. Such BMPs would include reviewing the need for beach nourishment, dredging and dock projects, identifying alternatives that would minimize impacts on eelgrass; using Best Available Technology (BAT) to minimize dredging and dock construction effects; using materials on docks and piers that could promote eelgrass growth beneath these structures; (2) Educate boat owners and property owners as to the importance of eelgrass within Newport Harbor so that they take “ownership” in their project and view eelgrass as a positive outcome of their project; and (3) Maintaining and creating a sustainable eelgrass population in the Stable Eelgrass Zone should the threshold value of eelgrass populations in Newport Harbor fall below the minimum amount of 20 acres.

Close coordination will be needed between the City of Newport Beach, the Department of Fish and Game, and the National Marine Fisheries Service to develop special conditions that will be effective in making the Newport Beach Long-Term Eelgrass Management Plan a success, and at the same time, responsive to agency concerns.

To achieve this goal, eelgrass sustainability populations should be maintained and if needed, eelgrass sustainability areas created for future public and private sector projects in Newport Harbor. The concept would involve (1) maintaining a base amount of eelgrass based upon identified eelgrass threshold capacity measurements and using BMPs to ensure this threshold capacity is maintained, (2) implementing programs to maintain and establish sustainable eelgrass populations in areas affected by disturbances, or into the created habitat using innovative and cost-efficient methods if necessary to maintain a critical eelgrass mass (20 acres), and (3) monitoring over the long term, the success of the sustainable eelgrass population.

Traditionally, eelgrass transplants for small to medium-sized projects have been conducted by using an anchor-bundle method by which eelgrass is collected from donor sites, bundled into units, and then replanted by divers in predetermined planting grids (Fonseca et al., 1982). However, for large-scale mitigation and restoration projects (on the order of small to large projects it may be necessary to utilize alternative transplant methodologies using eelgrass seed banks and seed dispersal methods (Granger et al., 2002) that will have less environmental impacts than collecting large amounts of eelgrass donor material. Safety concerns for deploying teams of divers to conduct eelgrass transplant using the anchor/bundle method may also require the implementation of alternative transplant methodologies such as the remote deployment of prefabricated eelgrass structural units (Short et al., 2002). Labor costs can potentially be reduced. Such experimental programs have been initially established for San Francisco Bay (Michael Josselyn, Wetland Research Associates, Inc. pers. com with R. Ware, March 2008). Due to the expected large size of the mitigation site, transplant methodologies should be evaluated and tested within Newport Bay prior to the creation of the shallow water habitat to determine the most effective and cost-efficient methods to employ for large-scale eelgrass transplants.

If needed, sustainable eelgrass population could be established in the Stable Eelgrass Zone (Figures 17 and 19). For example, the deeper channel waters beneath Mooring Area B seaward of the southern perimeter of Balboa Island encompass a maximum of approximately 28 acres of bayfloor that could be modified to support a sustainable eelgrass population(Figure 19) although several sites within the Stable Eelgrass Zone could be utilized for this purpose. Being within the Stable Eelgrass Zone, this site exhibits good water circulation, and the nearby shoreline along South Bay Front is colonized by high eelgrass cover. While depths within this area are currently too deep to support eelgrass, a selected site(s) could be engineered to provide for (1) long-term stability from the effects of sediment scour and/or sediment deposition, (2) appropriate depth ranges to support a sustainable eelgrass population, and (3) adequate depths to maintain safe navigation and boating. The creation of new shallow-water habitat in the harbor would also present an opportunity to establish both a confined disposal site to manage contaminated, dredge sediments from Newport Bay dredging projects as well as maintain a sustainable eelgrass population. Similar sites have been created in San Diego Bay near North Island Naval Air Station (Pondella et al., 2006). A 40+ acre shallow water eelgrass mitigation site is proposed within Outer Los Angeles Harbor as mitigation for loss of shallow water habitat associated with the Port of Los Angeles Pier 300 project.

Figure 19. Potential Eelgrass Sustainability Locations in the Stable Eelgrass Zone

4.5 Steps Forward

1. **Identify appropriate needs relative to future watershed and harbor activities to gauge the extent of required sustainable eelgrass management. Develop an ecosystem approach Eelgrass Management Plan (EMP) rather than managing eelgrass project on an incremental basis.**

2. **Meet with stakeholders and identify concerns, constraints, and permitting issues based on what will be required for future dredging and infrastructure improvements in Newport Harbor.** It will be critical to assess the environmental permitting and fiscal constraints of the program early on to assess the ability of the City to implement an Eelgrass Management Plan. Early agency involvement with the Coastal Commission, U.S Army Corps of Engineers, State Lands Commission, State Water Resources Control Board, and resource agencies (NMFS, USFWS, and CDFG) is critical to ensure that there is sufficient agency understanding and support for such a critical undertaking.

3. **The EMP will promote a system-based approach; the key metric of eelgrass protection is the maintenance of a sustainable shallow water eelgrass population of at least 20 acres.** The focus of the City's management will be to protect and promote shallow water eelgrass populations and as long as the sustainable eelgrass population is above 20 acres, no more than 2 acres of eelgrass impacts will be permitted per year conditioned on compliance with best management practices for avoiding eelgrass disturbance where possible. Should the shallow water eelgrass population fall below 20

acres, increased mitigation measures and decreased allowable annual impact will be implemented in a phased manner.

4. **The City of Newport Beach will assume lead responsibility for the preparation and implementation of the Eelgrass Management Plan.** The City will enforce compliance with the plan, subject to agency oversight. Consistent with its management role, the City, rather than individual residents, will be responsible for surveying and data gathering, while relieving individual property owners of a burden they generally lack the expertise to effectively carry.

5. **The City will of Newport Beach will identify primary and alternative locations in the Stable Eelgrass Zone capable of supporting the maximum amount of sustainable eelgrass required for future projects should it be necessary to create additional Stable Eelgrass Zone eelgrass populations.** Conduct coastal engineering and marine biological surveys to identify those areas with the Stable Eelgrass Zone that have a potential to be utilized for mitigation bank sites. Conduct side scan sonar mapping surveys, physical modeling, and field studies in potential sustainable eelgrass areas to evaluate erosion, sedimentation, and other process that will be required to refine site selection.

6. **The City will prepare a draft Eelgrass Management Plan (DEMP) and negotiate a Final Stable Eelgrass Zone Management Plan (FEMP) with the National Marine Fisheries Service, the California Department of Fish and Game, the U.S. Army Corps of Engineers, and the California Coastal Commission.** Upon completion of the FEMP, the City shall commence review of the plan for consistency with provisions of the City of Newport Beach Local Coastal Plan and the Regional General Dredging Permit (RGP).

7. **Once in place, the City will implement and manage the FEMP. Following implementation, the City will review the success of the EMP at five-year intervals to determine the effectiveness of the program, identify any required changes to the program, and implement if necessary, adaptive management to ensure the key program metrics are being met.**

8. **Establish an Eelgrass Management Plan Website.** Lastly, the City should consider establishing a website that will track project implementation and achievement of key metrics for public review. This will also assist the City in providing suggested public educational outreach for the project

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5.0 REFERENCES

Allen, L. A. 1976. Abundance, Diversity, Seasonality and Community Structure of the Fish Populations of Newport Bay, California. M.S. Thesis, California State University, Fullerton. 108 pp.

Backman, T.W. and D. C. Barilotti 1976. Irradiance and reduction: Effects on standing crops of the eelgrass *Zostera marina* in a coastal lagoon. Mar. Biol. (Berl) 34:33–40.

Barnard, J. L., and D. J. Reish 1959. Ecology of Amphipoda and Polychaeta of Newport Bay, California. Allan Hancock Foundation Publication. Occasional Paper No. 21. 106 pp.

Beal, J. L. and B. S. Schmit. 2000. Chapter 4. The effects of dock height on light irradiance (PAR) and seagrass (*Halodule wrightii* and *Syringodium filiforme*) cover. Pages 43–63 *in:* Stephen A. Bortone, PhD, ed. Seagrasses: Monitoring, Ecology, Physiology, and Management. CRC Press, Boca Raton. 318 pp.

CDFG (California Department of Fish and Game). 1953. Biological survey: Lower Newport Bay. Report to the Santa Ana Regional Water Pollution Control Board. Feb 10, 1953. Code No. 58-8-8.

Chambers Group, Inc. and Coastal Resources Management. 1998. Pre-dredging eelgrass survey in Lower Newport Bay. Prepared for the U.S. Army Corps of Engineers. Los Angeles District. 15 pp. plus figures and appendices.

Chambers Group, Inc. and Coastal Resources Management. 1999. Lower Newport Harbor eelgrass restoration project field reconnaissance report. Prepared for the U.S. Army Corps of Engineers. Los Angeles District. 18 pp. plus figures and appendices. August 1999.

Chambers Group, Inc. 2005. Newport Dunes eelgrass survey, December 2004. Prepared for Moffatt & Nichol Engineers. February 2005.

Chambers Group, Inc. 2007. Newport Dunes eelgrass, *Caulerpa*, and oyster survey. Prepared for Moffatt & Nichol Engineers. November 2007.

Coastal Resources Management, Inc. (CRM) 1999. Grand Canal post-dredging eelgrass impact analysis. Prepared for the City of Newport Beach Public Works Department. May 3rd, 1999.

Coastal Resources Management, Inc. (CRM) 2002. City of Newport Beach Local Coastal Plan. Biological Appendix. Prepared for the City of Newport Beach Planning Department. Various Paging. December 2002.

Coastal Resources Management, Inc. (CRM) 2005. Final report. Distribution and abundance of eelgrass (*Zostera marina*) in Newport Bay. 2003–2004 eelgrass habitat mapping project. Bulkhead to pierhead line surveys. Prepared for the City of Newport Beach

Harbor Resources Division. April 2005. 30 pp. Maps on the City website: http://www6.city.newport-beach.ca.us/website/InteractiveMap/map.asp

Coastal Resources Management, Inc. (CRM) 2008. Distributional maps of eelgrass (*Zostera marina*) in Newport Bay. 2006–2008 eelgrass habitat mapping project. Shallow water (bulkhead to pierhead line surveys) and deeper channel survey results. Prepared for the City of Newport Beach Harbor Resources Division and the City of Newport Beach GIS Department. Maps on the City website: http://www6.city.newport-beach.ca.us/website/InteractiveMap/map.asp

Coastal Resources Management, Inc. (CRM). (In Progress). Eelgrass (*Zostera marina*) distribution and abundance in Newport Bay and abiotic influences on its distribution, 2003–2009. In preparation under contract to the City of Newport Beach Harbor Resources Department.

County of Orange, 2003. Report of the Regional Monitoring Program for the Newport By/San Diego Creek Watershed Nutrient TMDL (Resolution No 98-0 as amended by Resolution No 90-100. Prepared with the Cities of Irvine, Tustin, Newport Beach, Lake forest, Santa Ana, Orange, Costa Mesa, and the Irvine Company and the Irvine Ranch Water District. November 2004. 99 pp.

County of Orange, 2004. Report of the Regional Monitoring Program for the Newport By/San Diego Creek Watershed Nutrient TMDL (Resolution No 98-0 as amended by Resolution No 90-100. Prepared with the Cities of Irvine, Tustin, Newport Beach, Lake forest, Santa Ana, Orange, Costa Mesa, and the Irvine Company and the Irvine Ranch Water District. November 2004. 82 pp.

County of Orange, 2004. Report of the Regional Monitoring Program for the Newport By/San Diego Creek Watershed Nutrient TMDL (Resolution No 98-0 as amended by Resolution No 90-100. Prepared with the Cities of Irvine, Tustin, Newport Beach, Lake forest, Santa Ana, Orange, Costa Mesa, and the Irvine Company and the Irvine Ranch Water District. November 2004. 28 pp.

Coyer, J. A., K. A. Miller, J. M. Engle, J. Veldsink, A. Cabello-Pasini, W.T. Stam, and J. L. Olsen. Eelgrass meadows in the California Channel Islands and adjacent coast reveal a mosaic of two species, evidence for introgression and variable clonality. Annals of Botany 101: 73–87, 2008

Dawson, C.M. 1963. Benthic ecology in the entrance channel of Newport Bay, California. M.S. Thesis, University of Southern California. 112 pp.

Dennison, W.C. 1987. Effects of light on seagrass photosynthesis, growth, and depth distribution. Aquat. Bot. 27:15–26.

Duarte, C.M. 1991 Seagrass depth limits. Aquat. Bot., 40:363–377.

Fonseca, M.S., W.S. Kenworthy, and G.W. Thayer. 1982. *A low-cost planting technique for eelgrass (Zostera marina L.).* Coastal Engineering Tech. Aid. No. 82-66. Coastal Engineering Research Center, Kingman Bldg., Ft. Belvoir, Virginia. 15 pp.

Granger, S. , M. Traber, S.W Nixon, and R. Keyes. 2002. A practical guide for the use of seeds in eelgrass (*Zostera marina* L.) restoration. Part 1. Collection, processing, and storage. M. Schwartz (ed). Rhoad Island Sea Grant, Narragansett., R. I. 20 pp.

Hardy, R. A. 1970. The marine environment in Upper Newport and Sunset Bays, Orange County, California. California Department of Fish and Game Report. MMR Reference No. 70-10. 84 pp.

Hoffman, R.S. 1986. Fishery utilization of eelgrass (*Zostera marina*) beds and non-vegetated shallow water areas in San Diego Bay. National Marine Fisheries Service Southwest Region, Administrative Report SWR-86-4. 29 pp.

Hoffman, R.S. 1990. Fishery utilization of natural versus transplanted eelgrass beds in Mission Bay, San Diego, California. Pages 58–64 in: K.W. Merkel and R. S. Hoffman, eds. Proceedings of the California Eelgrass Symposium. May 27 and 28, 1988. Chula Vista, California. 78 pp.

Hoffman, R.S. 1991. Relative fishery values of natural versus transplanted eelgrass beds Zostera marina) in Southern California. in: H. S. Bolton (ed). Coastal Wetlands. Coastal Zone '91. Seventh Symposium on Coastal and Ocean Management. Long Beach, California. July 8–12, 1991.

Marine Biological Consultants (MBC) and the Southern California Coastal Water Research Project (SCCWRP). 1980 (Dec). Irvine Ranch Water District Upper Newport Bay and Stream Augmentation Program. Final Report. October 1979–August 1980.

MBC Applied Environmental Sciences (MBC). 1986. Infauna and epifauna associated with transplants of eelgrass (Zostera marina) in Southern California. Prepared for Maguire Thomas Partners, The Huntington Partnership, National Marine Fisheries Service, and the U.S. Fish and Wildlife Service. 48 pp.

MBC Applied Environmental Sciences (MBC). 1987. Mola Development Corporation eelgrass (*Zostera marina*) mitigation project. Transplant monitoring survey results and evaluation of transplant success. Prepared for the Mola Corporation, Huntington Beach, Ca. November, 1987.

MBC Applied Environmental Sciences (MBC). 2004. Army Corps of Engineers Upper Newport Bay eelgrass mitigation project transplant report and monitoring plan", May 2004. Prepared for the U.S. Army Corps of Engineers, Los Angeles District. May 2004.

Merkel and Associates, Inc. 2003. Pre-construction eelgrass survey and *Caulerpa taxifolia* protocol survey in support of the Newport Bay Harbor Maintenance Dredging Project. Prepared for Brittan Industries, Bakersfield, Ca. August 18, 2003. 4 pp. plus appendices.

Merkel, K. 1990. Eelgrass transplanting in San Diego Bay. Pages 24–28 in: K. W. Merkel and R. S Hoffman (editors), Proceeding of the California Eelgrass Symposium, 27-28 May, 1988. Chula Vista, Ca. 78 pp.

National Marine Fisheries Service. 1991. *Southern California Eelgrass Mitigation Policy*. National Marine Fisheries Service, Southwest Region, Long Beach, CA. 11th Revision.

National Marine Fisheries Service. 2003. Newport Bay down-looking sonar survey maps of the harbor entrance channel and Corona del Mar Reach, Newport Harbor. Prepared for the City of Newport Beach Harbor Resources Division. Maps available on City website http://www6.city.newport-beach.ca.us/website/InteractiveMap/map.asp

National Marine Fisheries Service (NMFS). 2008. Essential Fish Habitat (EFH) evaluation for the Balboa Marina Project, Newport Beach, Ca. February, 2008. Prepared by Robert Hoffman, NMFS, Long Beach, CA. 4 pp.

Orth, R. J. , K. L. Heck, and J. van Montrans. 1984. Faunal communities in seagrass beds: A review of the influence of plant structure and prey characteristics on predator-prey relationships. Estuaries 7(4a):339–350.

Phillips, R. C. 1972. Ecological life history of *Zostera marina* L (eelgrass) in Puget Sound, Washington. Ph.D. Diss. Univ. of Washington, Seattle. 154 pp.

Phillips, R. C. 1984. The ecology of eelgrass meadows in the Pacific Northwest: A community profile. FWS/OBS-84/24. 85 pp.

Phillips, R.C. and E. G. Menez. 1988. Seagrasses. Smithsonian Contributions to the Marine Sciences: 34.

Phillips, R.C. and S. W. Echeverria. 1990. *Zostera asiatica* Miki on the Pacific Coast of North America. Pacific Science Vol 44 (2):130–134.

Pondella, D. J, Larry G. Allen, M. T. Craig, and B. Gintert. 2006. Evaluation of eelgrass mitigation and fishery enhancement structures in San Diego Bay, California. Bull Mar Sci,78(1):115–131.

Posjepal, M. A. 1969. The Population Ecology of the Benthic ichthyofauna of Upper Newport Bay. M. S. Thesis, University of California, Irvine. 146 pp.

California Department of Fish and Game (CDFG). 1953. Biological survey: Lower Newport Bay. Report to the Santa Ana Regional Water Quality Control Board. Code No. 58-8-8. 32 pp.

Smith, R. D. 1989. Anaerobic metabolism in the roots of the seagrass Zostera marina L. PhD dissertation, The University of Chicago.

Short, Fred T., Catherine Short, and Carrie L. Burdick-Whitney. 2002. A Manual for Community Based Restoration. Jackson Estuarine Laboratory, University of New Hampshire. July 15, 2002. 57 pp.

Southern California Coastal Water Research Project. 2002. Macronutrient dynamics in Upper Newport Bay. Technical report 365. Prepared by Krista Kramer, Kenneth Schiff (SCCWRP), Rachel Kennison and Peggy Fong (UCLA).
July 31, 2002. 98 pp.

State Water Quality Control Board. 1965. An Oceanographic and Biological Survey of the Southern California Mainland Shelf. Publication Number 27. State of California, The Resources Agency. 231 pp.

Stevenson, R.E. and K.O. Emery. 1958. Marshlands at Newport Bay. Allan Hancock Foundation Publications. Occasional Paper No. 20. University of Southern California Press, Los Angeles, California.

Thayer, G.W., W. Judson Kenworthy, and M.S. Fonseca. 1984. The Ecology of Eelgrass Meadows of the Atlantic Coast: A Community Profile. U.S. Fish Wildl. Serv. FWS/OBS-84/02. 147 pp.

Thom R. M, A.B Borde, G.D Williams, J.A Southard, S.L Blanton, and D.L Woodruff. 2001. "Effects of multiple stressors on eelgrass restoration projects." In Proceedings of Puget Sound Research 2001, the fifth Puget Sound Research Conference, vol. 1, ed. Droscher, Toni. Puget Sound Water Quality Action Team, Olympia, WA.

Ware, R. R. 1993. Eelgrass (*Zostera marina*) in Southern California bays and wetlands with special emphasis on Orange County, California. Shore and Beach 91:20–30.

White, W. S. 1977. Taxonomic Composition, Abundance, Distribution, and Seasonality of Fish Eggs and Larvae in Newport Bay, California. M. A. Thesis, California State University, Fullerton.

Weide, D. L. 1981. Appendix 1: The geologic setting and evolution of Ora-193. Pac. Coast Archaeol. Soc. 17(2&3):81–93.

Zimmerman, R. C., J. L. Reguzzoni, S. Wyllie-Echeverria, M. Josselyn and R. S. Alberte. 1991. Assessment of environmental suitability for growth of *Zostera marina* L. (eelgrass) in San Francisco Bay. Aquatic Botany 39:353–366.

ATTACHMENT 1

SITE LOCATION MAP WHERE EELGRASS WAS RECORDED PRIOR TO 1976
Source: CRM, Inc.